

US008636766B2

(12) **United States Patent**
Milliman et al.

(10) **Patent No.:** **US 8,636,766 B2**
(45) **Date of Patent:** **Jan. 28, 2014**

(54) **SURGICAL STAPLING APPARATUS
INCLUDING SENSING MECHANISM**

(71) Applicant: **Covidien LP**, Mansfield, MA (US)

(72) Inventors: **Keith L. Milliman**, Bethel, CT (US);
Frank J. Viola, Sandy Hook, CT (US);
Joseph P. Orban, Norwalk, CT (US);
Randolph F. Lehn, Stratford, CT (US)

(73) Assignee: **Covidien LP**, Mansfield, MA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/690,413**

(22) Filed: **Nov. 30, 2012**

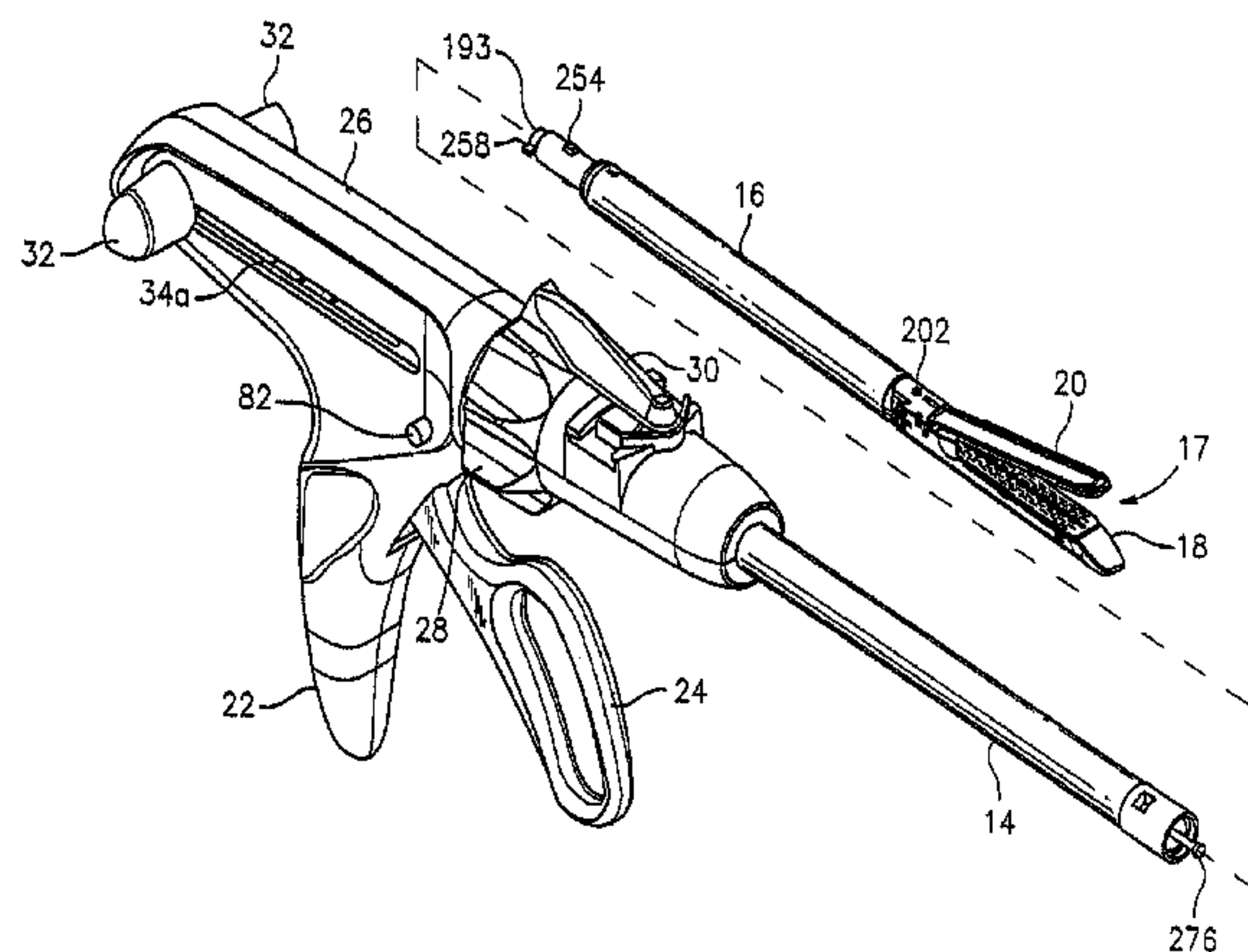
(65) **Prior Publication Data**

US 2013/0140342 A1 Jun. 6, 2013

Related U.S. Application Data

(60) Continuation of application No. 13/585,350, filed on Aug. 14, 2012, now Pat. No. 8,342,377, which is a continuation of application No. 13/491,085, filed on Jun. 7, 2012, now Pat. No. 8,292,152, which is a continuation of application No. 13/295,140, filed on Nov. 14, 2011, now Pat. No. 8,256,656, which is a continuation of application No. 13/285,355, filed on Oct. 31, 2011, now Pat. No. 8,210,416, which is a continuation of application No. 12/793,196, filed on Jun. 3, 2010, now Pat. No. 8,070,033, which is a continuation of application No. 12/494,617, filed on Jun. 30, 2009, now Pat. No. 8,083,118, which is a division of application No. 11/974,638, filed on Oct. 15, 2007, now Pat. No. 7,565,993, which is a continuation of application No. 11/489,212, filed on Jul. 19, 2006, now Pat. No. 7,303,107, which is a continuation of application No. 11/186,742, filed on Jul. 20, 2005, now abandoned, which is a continuation

(Continued)



(51) **Int. Cl.**
A61B 17/068 (2006.01)

(52) **U.S. Cl.**
USPC **606/219**; 606/139; 227/19; 227/175.2;
227/176.1

(58) **Field of Classification Search**
USPC 227/19, 175.1, 175.2, 176.1, 180.1;
606/139, 151, 153, 219
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

3,079,606 A 3/1963 Bobrov et al.
3,490,675 A 1/1970 Green et al.

(Continued)

FOREIGN PATENT DOCUMENTS

AU 198654765 9/1986
DE 2744824 4/1978

(Continued)

OTHER PUBLICATIONS

EP Search Report EP 06023618.9 date of completion Feb. 16, 2007.

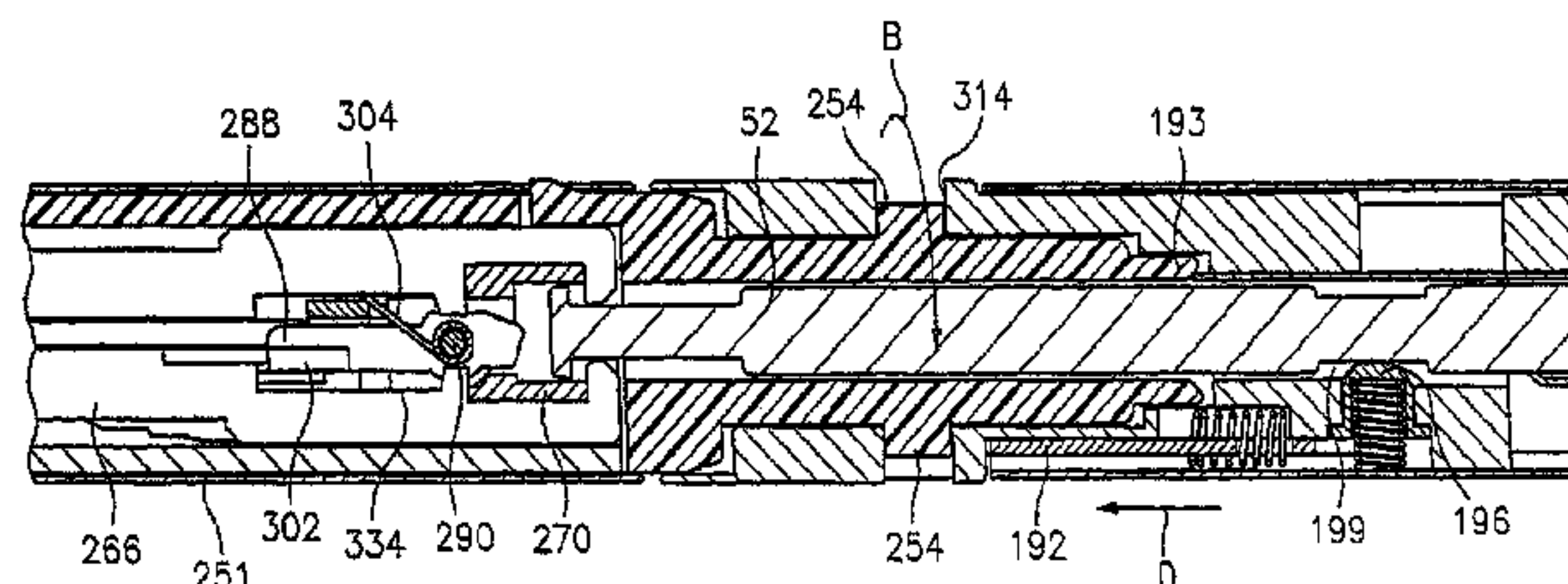
(Continued)

Primary Examiner — Scott A. Smith

(57) **ABSTRACT**

A surgical stapling device particularly suited for endoscopic procedures is described. The device includes a handle assembly and an elongated body extending distally from the handle assembly. The distal end of the elongated body is adapted to engage a disposable loading unit. A control rod having a proximal end operatively connected to the handle assembly includes a distal end extending through the elongated body. A control rod locking member is provided to prevent movement of the control rod until the disposable loading unit is fully secured to the elongated body of the stapling device.

10 Claims, 39 Drawing Sheets



Related U.S. Application Data

of application No. 10/983,288, filed on Nov. 5, 2004, now Pat. No. 6,953,139, which is a continuation of application No. 10/700,250, filed on Nov. 3, 2003, now abandoned, which is a continuation of application No. 10/014,004, filed on Dec. 10, 2001, now Pat. No. 6,669,073, which is a continuation of application No. 09/680,093, filed on Oct. 5, 2000, now Pat. No. 6,330,965, which is a division of application No. 09/561,567, filed on Apr. 28, 2000, now Pat. No. 6,241,139, which is a division of application No. 09/166,378, filed on Oct. 5, 1998, now Pat. No. 6,079,606, which is a division of application No. 08/935,980, filed on Sep. 23, 1997, now Pat. No. 5,865,361.

(56)

References Cited

U.S. PATENT DOCUMENTS

3,499,591 A 3/1970 Green
 3,777,538 A 12/1973 Weatherly et al.
 3,882,854 A 5/1975 Hulka et al.
 4,027,510 A 6/1977 Hildebrandt
 4,086,926 A 5/1978 Green et al.
 4,244,372 A 1/1981 Kapitanov et al.
 4,429,695 A 2/1984 Green
 4,473,077 A 9/1984 Noiles et al.
 4,505,414 A 3/1985 Filipi
 4,520,817 A 6/1985 Green
 4,589,413 A 5/1986 Malyshev et al.
 4,596,351 A 6/1986 Fedotov et al.
 4,602,634 A 7/1986 Barkley
 4,605,001 A 8/1986 Rothfuss et al.
 4,608,981 A 9/1986 Rothfuss et al.
 4,610,383 A 9/1986 Rothfuss et al.
 4,633,861 A 1/1987 Chow et al.
 4,633,874 A 1/1987 Chow et al.
 4,646,745 A 3/1987 Noiles
 4,671,445 A 6/1987 Barker et al.
 4,672,964 A 6/1987 Dee et al.
 4,700,703 A 10/1987 Resnick et al.
 4,703,887 A 11/1987 Clanton et al.
 4,728,020 A 3/1988 Green et al.
 4,752,024 A 6/1988 Green et al.
 4,763,669 A 8/1988 Jaeger
 4,784,137 A 11/1988 Kulik et al.
 4,863,088 A 9/1989 Redmond et al.
 4,869,415 A 9/1989 Fox
 4,880,015 A 11/1989 Nierman
 4,892,244 A 1/1990 Fox et al.
 4,955,959 A 9/1990 Tompkins et al.
 4,978,049 A 12/1990 Green
 4,991,764 A 2/1991 Mericle
 5,014,899 A 5/1991 Presty et al.
 5,031,814 A 7/1991 Tompkins et al.
 5,040,715 A 8/1991 Green et al.
 5,065,929 A 11/1991 Schulze et al.
 5,071,052 A 12/1991 Rodak et al.
 5,071,430 A 12/1991 deSalis et al.
 5,074,454 A 12/1991 Peters
 5,083,695 A 1/1992 Foslien et al.
 5,084,057 A 1/1992 Green et al.
 5,106,008 A 4/1992 Tompkins et al.
 5,111,987 A 5/1992 Moeinzadeh et al.
 5,129,570 A 7/1992 Schulze et al.
 5,141,144 A 8/1992 Foslien et al.
 5,152,279 A 10/1992 Wilk
 5,156,315 A 10/1992 Green et al.
 5,156,614 A 10/1992 Green et al.
 5,163,943 A 11/1992 Mohiuddin et al.
 5,170,925 A 12/1992 Madden et al.
 5,171,247 A 12/1992 Hughetti et al.
 5,173,133 A 12/1992 Morin et al.
 5,180,092 A 1/1993 Crainich

5,188,274 A 2/1993 Moeinzadeh et al.
 5,209,747 A 5/1993 Knoepfler
 5,220,928 A 6/1993 Oddsen et al.
 5,221,036 A 6/1993 Takase
 5,242,457 A 9/1993 Akopov et al.
 5,246,156 A 9/1993 Rothfuss et al.
 5,253,793 A 10/1993 Green et al.
 5,263,629 A 11/1993 Trumbull et al.
 RE34,519 E 1/1994 Fox et al.
 5,275,323 A 1/1994 Schulze et al.
 5,275,608 A 1/1994 Froman et al.
 5,282,807 A 2/1994 Knoepfler
 5,282,826 A 2/1994 Quadri
 5,289,963 A 3/1994 McGarry et al.
 5,307,976 A 5/1994 Olson et al.
 5,308,576 A 5/1994 Green et al.
 5,312,023 A 5/1994 Green et al.
 5,318,221 A 6/1994 Green et al.
 5,326,013 A 7/1994 Green et al.
 5,328,077 A 7/1994 Lou
 5,330,486 A 7/1994 Wilk
 5,330,502 A 7/1994 Hassler et al.
 5,332,142 A 7/1994 Robinson et al.
 5,336,232 A 8/1994 Green et al.
 5,344,061 A 9/1994 Crainich
 5,350,391 A 9/1994 Iacovelli
 5,352,238 A 10/1994 Green et al.
 5,354,311 A 10/1994 Kambin et al.
 5,356,064 A 10/1994 Green et al.
 5,358,506 A 10/1994 Green et al.
 5,364,001 A 11/1994 Bryan
 5,364,002 A 11/1994 Green et al.
 5,364,003 A 11/1994 Williamson, IV
 5,366,133 A 11/1994 Geiste
 5,374,277 A 12/1994 Hassler
 5,376,095 A 12/1994 Ortiz
 5,379,933 A 1/1995 Green et al.
 5,381,943 A 1/1995 Allen et al.
 5,382,255 A 1/1995 Castro et al.
 5,383,880 A 1/1995 Hooven
 5,383,888 A 1/1995 Zvenyatsky et al.
 5,389,098 A 2/1995 Tsuruta et al.
 5,395,033 A 3/1995 Byrne et al.
 5,395,034 A 3/1995 Allen et al.
 5,397,046 A 3/1995 Savage et al.
 5,397,324 A 3/1995 Carroll et al.
 5,403,312 A 4/1995 Yates et al.
 5,405,072 A 4/1995 Zlock et al.
 5,407,293 A 4/1995 Crainich
 5,413,268 A 5/1995 Green et al.
 5,415,334 A 5/1995 Williamson, IV et al.
 5,415,335 A 5/1995 Knodell, Jr.
 5,417,361 A 5/1995 Williamson, IV
 5,423,471 A 6/1995 Matri et al.
 5,425,745 A 6/1995 Green et al.
 5,431,322 A 7/1995 Green et al.
 5,431,323 A 7/1995 Smith et al.
 5,433,721 A 7/1995 Hooven et al.
 5,441,193 A 8/1995 Gravener
 5,445,304 A 8/1995 Plyley et al.
 5,447,265 A 9/1995 Vidal et al.
 5,452,837 A 9/1995 Williamson, IV et al.
 5,456,401 A 10/1995 Green et al.
 5,464,300 A 11/1995 Crainich
 5,465,895 A 11/1995 Knodel et al.
 5,467,911 A 11/1995 Tsuruta et al.
 5,470,007 A 11/1995 Plyley et al.
 5,470,010 A 11/1995 Rothfuss et al.
 5,472,132 A 12/1995 Savage et al.
 5,474,566 A 12/1995 Alesi et al.
 5,474,571 A 12/1995 Lang
 5,476,206 A 12/1995 Green et al.
 5,478,003 A 12/1995 Green et al.
 5,480,089 A 1/1996 Blewett
 5,482,197 A 1/1996 Green et al.
 5,484,095 A 1/1996 Green et al.
 5,484,451 A 1/1996 Akopov et al.
 5,485,947 A 1/1996 Olson et al.
 5,485,952 A 1/1996 Fontayne

(56)

References Cited

U.S. PATENT DOCUMENTS

5,486,185 A	1/1996	Freitas et al.	5,673,841 A	10/1997	Schulze et al.
5,487,499 A	1/1996	Sorrentino et al.	5,673,842 A	10/1997	Bittner et al.
5,487,500 A	1/1996	Knodel et al.	5,676,674 A	10/1997	Bolanos et al.
5,489,058 A	2/1996	Plyley et al.	5,680,981 A	10/1997	Mililli et al.
5,490,856 A	2/1996	Person et al.	5,680,982 A	10/1997	Schulze et al.
5,497,933 A	3/1996	DeFonzo et al.	5,680,983 A	10/1997	Plyley et al.
5,501,689 A	3/1996	Green et al.	5,690,269 A	11/1997	Bolanos et al.
5,505,363 A	4/1996	Green et al.	5,692,668 A	12/1997	Schulze et al.
5,507,426 A	4/1996	Young et al.	5,697,542 A	12/1997	Knodel et al.
5,518,163 A	5/1996	Hooven	5,702,409 A	12/1997	Rayburn et al.
5,518,164 A	5/1996	Hooven	5,704,534 A	1/1998	Huitema et al.
5,529,235 A	6/1996	Boiarski et al.	5,706,997 A	1/1998	Green et al.
5,531,744 A	7/1996	Nardella et al.	5,709,334 A	1/1998	Sorrentino et al.
5,535,934 A	7/1996	Boiarski et al.	5,711,472 A	1/1998	Bryan
5,535,935 A	7/1996	Vidal et al.	5,713,505 A	2/1998	Huitema
5,535,937 A	7/1996	Boiarski et al.	5,715,988 A	2/1998	Palmer
5,540,375 A	7/1996	Bolanos et al.	5,716,366 A	2/1998	Yates
5,542,594 A	8/1996	McKean et al.	5,718,359 A	2/1998	Palmer
5,549,628 A	8/1996	Cooper et al.	5,725,536 A	3/1998	Oberlin et al.
5,551,622 A	9/1996	Yoon	5,725,554 A	3/1998	Simon et al.
5,553,765 A	9/1996	Knodel et al.	5,728,110 A	3/1998	Vidal et al.
5,554,164 A	9/1996	Wilson et al.	5,732,806 A	3/1998	Foshee et al.
5,554,169 A	9/1996	Green et al.	5,735,848 A	4/1998	Yates et al.
5,560,530 A	10/1996	Bolanos et al.	5,743,456 A	4/1998	Jones et al.
5,560,532 A	10/1996	DeFonzo et al.	5,749,893 A	5/1998	Vidal et al.
5,562,239 A	10/1996	Boiarski et al.	5,752,644 A	5/1998	Bolanos et al.
5,562,241 A	10/1996	Knodel et al.	5,762,255 A	6/1998	Chrisman et al.
5,562,682 A	10/1996	Oberlin et al.	5,762,256 A	6/1998	Mastri et al.
5,562,701 A	10/1996	Huitema et al.	5,769,303 A	6/1998	Knodel et al.
5,564,615 A	10/1996	Bishop et al.	5,769,892 A	6/1998	Kingwell
5,571,116 A	11/1996	Bolanos et al.	5,772,099 A	6/1998	Gravener
5,573,169 A	11/1996	Green et al.	5,772,673 A	6/1998	Cuny et al.
5,573,543 A	11/1996	Akopov et al.	5,779,130 A	7/1998	Alesi et al.
5,575,799 A	11/1996	Bolanos et al.	5,779,131 A	7/1998	Knodel et al.
5,575,803 A	11/1996	Cooper et al.	5,779,132 A	7/1998	Knodel et al.
5,577,654 A	11/1996	Bishop	5,782,396 A	7/1998	Mastri et al.
5,579,107 A	11/1996	Wright et al.	5,782,397 A	7/1998	Koukline
5,582,617 A	12/1996	Klieman et al.	5,782,834 A	7/1998	Lucey et al.
5,584,425 A	12/1996	Savage et al.	5,785,232 A	7/1998	Vidal et al.
5,586,711 A	12/1996	Plyley et al.	5,797,536 A	8/1998	Smith et al.
5,588,580 A	12/1996	Paul et al.	5,797,537 A	8/1998	Oberlin et al.
5,588,581 A	12/1996	Conlon et al.	5,797,538 A	8/1998	Heaton et al.
5,597,107 A	1/1997	Knodel et al.	5,810,811 A	9/1998	Yates et al.
5,601,224 A	2/1997	Bishop et al.	5,810,855 A	9/1998	Rayburn et al.
5,605,272 A	2/1997	Witt et al.	5,814,055 A	9/1998	Knodel et al.
5,607,095 A	3/1997	Smith et al.	5,814,057 A	9/1998	Oi et al.
5,615,820 A	4/1997	Viola	5,816,471 A	10/1998	Plyley et al.
5,618,291 A	4/1997	Thompson et al.	5,817,109 A	10/1998	McGarry et al.
5,624,452 A	4/1997	Yates	5,820,009 A	10/1998	Melling et al.
5,626,587 A	5/1997	Bishop et al.	5,823,066 A	10/1998	Huitema et al.
5,628,446 A	5/1997	Geiste et al.	5,826,776 A	10/1998	Schulze et al.
5,630,539 A	5/1997	Plyley et al.	5,829,662 A	11/1998	Allen et al.
5,630,540 A	5/1997	Blewett	5,833,695 A	11/1998	Yoon
5,630,541 A	5/1997	Williamson, IV et al.	5,836,147 A	11/1998	Schnipke
5,632,432 A	5/1997	Schulze et al.	5,855,311 A	1/1999	Hamblin et al.
5,634,584 A	6/1997	Okorochoa et al.	5,862,972 A	1/1999	Green et al.
5,636,780 A	6/1997	Green et al.	5,865,361 A	2/1999	Milliman et al.
5,645,209 A	7/1997	Green et al.	5,871,135 A	2/1999	Williamson, IV et al.
5,647,526 A	7/1997	Green et al.	5,873,873 A	2/1999	Smith et al.
5,651,491 A	7/1997	Heaton et al.	5,878,938 A	3/1999	Bittner et al.
5,653,373 A	8/1997	Green et al.	5,893,506 A	4/1999	Powell
5,653,374 A	8/1997	Young et al.	5,894,979 A	4/1999	Powell
5,653,721 A	8/1997	Knodel et al.	5,897,562 A	4/1999	Bolanos et al.
5,655,698 A	8/1997	Yoon	5,901,895 A	5/1999	Heaton et al.
5,657,921 A	8/1997	Young et al.	5,911,352 A	6/1999	Racenet et al.
5,658,300 A	8/1997	Bitto et al.	5,911,353 A	6/1999	Bolanos et al.
5,662,258 A	9/1997	Knodel et al.	5,918,791 A	7/1999	Sorrentino et al.
5,662,259 A	9/1997	Yoon	5,919,198 A	7/1999	Graves, Jr. et al.
5,662,260 A	9/1997	Yoon	5,922,001 A	7/1999	Yoon
5,662,662 A	9/1997	Bishop et al.	5,931,847 A	8/1999	Bittner et al.
5,662,666 A	9/1997	Onuki et al.	5,941,442 A	8/1999	Geiste et al.
5,665,085 A	9/1997	Nardella	5,954,259 A	9/1999	Viola et al.
5,667,517 A	9/1997	Hooven	5,964,774 A	10/1999	McKean et al.
5,669,544 A	9/1997	Schulze et al.	5,980,510 A	11/1999	Tsonton et al.
5,673,840 A	10/1997	Schulze et al.	5,988,479 A	11/1999	Palmer
			6,004,335 A	12/1999	Vaitekunas et al.
			6,010,054 A	1/2000	Johnson et al.
			6,032,849 A	3/2000	Mastri et al.
			6,045,560 A	4/2000	McKean et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

6,063,097	A	5/2000	Oi et al.	7,032,799	B2	4/2006	Viola et al.
6,079,606	A	6/2000	Milliman et al.	7,044,352	B2	5/2006	Shelton, IV et al.
6,099,551	A	8/2000	Gabbay	7,044,353	B2	5/2006	Mastri et al.
6,109,500	A	8/2000	Alli et al.	7,055,730	B2	6/2006	Ehrenfels et al.
6,131,789	A	10/2000	Schulze et al.	7,055,731	B2	6/2006	Shelton, IV et al.
6,131,790	A	10/2000	Piraka	7,059,508	B2	6/2006	Shelton, IV et al.
6,155,473	A	12/2000	Tompkins et al.	7,070,083	B2	7/2006	Jankowski
6,197,017	B1	3/2001	Brock et al.	7,083,075	B2	8/2006	Swayze et al.
6,202,914	B1	3/2001	Geiste et al.	7,097,089	B2	8/2006	Marczyk
6,241,139	B1	6/2001	Milliman et al.	7,111,769	B2	9/2006	Wales et al.
6,250,532	B1	6/2001	Green et al.	7,114,642	B2	10/2006	Whitman
6,264,086	B1	7/2001	McGuckin, Jr.	7,121,446	B2	10/2006	Arad et al.
6,264,087	B1	7/2001	Whitman	7,128,253	B2	10/2006	Mastri et al.
6,269,977	B1	8/2001	Moore	7,128,254	B2	10/2006	Shelton, IV et al.
6,279,809	B1	8/2001	Nicolo	7,140,527	B2	11/2006	Ehrenfels et al.
6,315,183	B1	11/2001	Piraka	7,140,528	B2	11/2006	Shelton, IV
6,315,184	B1	11/2001	Whitman	7,143,923	B2	12/2006	Shelton, IV et al.
6,325,810	B1	12/2001	Hamilton et al.	7,143,924	B2	12/2006	Scirica et al.
6,330,965	B1	12/2001	Milliman et al.	7,143,925	B2	12/2006	Shelton, IV et al.
6,391,038	B2	5/2002	Vargas et al.	7,143,926	B2	12/2006	Shelton, IV et al.
6,398,797	B2	6/2002	Bombard et al.	7,147,138	B2	12/2006	Shelton, IV
6,436,097	B1	8/2002	Nardella	7,159,750	B2	1/2007	Racenet et al.
6,439,446	B1	8/2002	Perry et al.	7,168,604	B2	1/2007	Milliman
6,443,973	B1	9/2002	Whitman	7,172,104	B2	2/2007	Scirica et al.
6,463,623	B2	10/2002	Ahn et al.	7,188,758	B2	3/2007	Viola et al.
6,478,804	B2	11/2002	Vargas et al.	7,207,471	B2	4/2007	Heinrich et al.
6,488,196	B1	12/2002	Fenton, Jr.	7,213,736	B2	5/2007	Wales et al.
6,503,257	B2	1/2003	Grant et al.	7,225,963	B2	6/2007	Scirica
6,503,259	B2	1/2003	Huxel et al.	7,225,964	B2	6/2007	Mastri et al.
6,505,768	B2	1/2003	Whitman	7,238,195	B2	7/2007	Viola
6,544,274	B2	4/2003	Danitz et al.	7,246,734	B2	7/2007	Shelton, IV
6,554,844	B2	4/2003	Lee et al.	7,258,262	B2	8/2007	Mastri et al.
6,565,554	B1	5/2003	Niemeyer	7,278,562	B2	10/2007	Mastri et al.
6,587,750	B2	7/2003	Gerbi et al.	7,278,563	B1	10/2007	Green
6,592,597	B2	7/2003	Grant et al.	7,287,682	B1	10/2007	Ezzat et al.
6,594,552	B1	7/2003	Nowlin et al.	7,293,685	B2	11/2007	Ehrenfels et al.
6,602,252	B2	8/2003	Mollenauer	7,296,722	B2	11/2007	Ivanko
6,612,053	B2	9/2003	Liao	7,296,724	B2	11/2007	Green et al.
6,619,529	B2	9/2003	Green et al.	7,296,772	B2	11/2007	Wang
D480,808	S	10/2003	Wells et al.	7,300,444	B1	11/2007	Nielsen et al.
6,644,532	B2	11/2003	Green et al.	7,303,107	B2	12/2007	Milliman et al.
6,656,193	B2	12/2003	Grant et al.	7,303,108	B2	12/2007	Shelton, IV
6,669,073	B2	12/2003	Milliman et al.	7,308,998	B2	12/2007	Mastri et al.
6,681,978	B2	1/2004	Geiste et al.	7,326,232	B2	2/2008	Viola et al.
6,698,643	B2	3/2004	Whitman	7,328,828	B2	2/2008	Ortiz et al.
6,716,232	B1	4/2004	Vidal et al.	7,328,829	B2	2/2008	Arad et al.
6,722,552	B2	4/2004	Fenton, Jr.	7,334,717	B2	2/2008	Rethy et al.
6,731,473	B2	5/2004	Li et al.	7,354,447	B2	4/2008	Shelton, IV et al.
6,755,338	B2	6/2004	Hahnen et al.	7,357,287	B2	4/2008	Shelton, IV et al.
6,783,524	B2	8/2004	Anderson et al.	7,364,061	B2	4/2008	Swayze et al.
6,786,382	B1	9/2004	Hoffman	7,367,485	B2	5/2008	Shelton, IV et al.
6,808,262	B2	10/2004	Chapoy et al.	7,377,928	B2	5/2008	Zubik et al.
6,817,509	B2	11/2004	Geiste et al.	7,380,695	B2	6/2008	Doll et al.
6,830,174	B2	12/2004	Hillstead et al.	7,380,696	B2	6/2008	Shelton, IV et al.
6,835,199	B2	12/2004	McGuckin, Jr. et al.	7,396,356	B2	7/2008	Mollenauer
6,843,403	B2	1/2005	Whitman	7,398,907	B2	7/2008	Racenet et al.
RE38,708	E	3/2005	Bolanos et al.	7,399,310	B2	7/2008	Edoga et al.
6,877,647	B2	4/2005	Green et al.	7,401,720	B1	7/2008	Durrani
6,879,880	B2	4/2005	Nowlin et al.	7,401,721	B2	7/2008	Holsten et al.
6,889,116	B2	5/2005	Jinno	7,404,508	B2	7/2008	Smith et al.
6,905,057	B2	6/2005	Swayze et al.	7,404,509	B2	7/2008	Ortiz et al.
6,945,444	B2	9/2005	Gresham	7,407,074	B2	8/2008	Ortiz et al.
6,953,138	B1	10/2005	Dworak et al.	7,407,075	B2	8/2008	Holsten et al.
6,953,139	B2	10/2005	Milliman et al.	7,407,077	B2	8/2008	Ortiz et al.
6,959,852	B2	11/2005	Shelton, IV et al.	7,407,078	B2	8/2008	Shelton, IV et al.
6,962,594	B1	11/2005	Thevenet	7,416,101	B2	8/2008	Shelton, IV et al.
6,964,363	B2	11/2005	Wales et al.	7,419,080	B2	9/2008	Smith et al.
6,978,921	B2	12/2005	Shelton, IV et al.	7,419,081	B2	9/2008	Ehrenfels et al.
6,981,628	B2	1/2006	Wales	7,419,495	B2	9/2008	Menn et al.
6,986,451	B1	1/2006	Mastri et al.	7,422,139	B2	9/2008	Shelton, IV et al.
6,988,649	B2	1/2006	Shelton, IV et al.	7,424,965	B2	9/2008	Racenet et al.
6,991,627	B2	1/2006	Madhani et al.	7,431,189	B2	10/2008	Shelton, IV et al.
6,994,714	B2	2/2006	Vargas et al.	7,431,730	B2	10/2008	Viola
7,000,818	B2	2/2006	Shelton, IV et al.	7,434,715	B2	10/2008	Shelton, IV et al.
7,000,819	B2	2/2006	Swayze et al.	7,434,717	B2	10/2008	Shelton, IV et al.
				7,438,208	B2	10/2008	Larson
				7,438,209	B1	10/2008	Hess et al.
				7,441,684	B2	10/2008	Shelton, IV et al.
				7,441,685	B1	10/2008	Boudreaux

(56)

References Cited

U.S. PATENT DOCUMENTS

7,448,525 B2	11/2008	Shelton, IV et al.	7,658,311 B2	2/2010	Boudreaux
7,451,904 B2	11/2008	Shelton, IV	7,658,312 B2	2/2010	Vidal et al.
7,455,208 B2	11/2008	Wales et al.	7,665,646 B2	2/2010	Prommersberger
7,455,676 B2	11/2008	Holsten et al.	7,665,647 B2	2/2010	Shelton, IV et al.
7,458,494 B2	12/2008	Matsutani et al.	7,669,746 B2	3/2010	Shelton, IV
7,461,767 B2	12/2008	Viola et al.	7,670,334 B2	3/2010	Hueil et al.
7,462,185 B1	12/2008	Knodel	7,673,780 B2	3/2010	Shelton, IV et al.
7,464,846 B2	12/2008	Shelton, IV et al.	7,673,781 B2	3/2010	Swayze et al.
7,464,847 B2	12/2008	Viola et al.	7,673,782 B2	3/2010	Hess et al.
7,464,848 B2	12/2008	Green et al.	7,673,783 B2	3/2010	Morgan et al.
7,464,849 B2	12/2008	Shelton, IV et al.	7,678,121 B1	3/2010	Knodel
7,467,740 B2	12/2008	Shelton, IV et al.	7,681,772 B2	3/2010	Green et al.
7,472,814 B2	1/2009	Mastri et al.	7,682,367 B2	3/2010	Shah et al.
7,472,815 B2	1/2009	Shelton, IV et al.	7,682,368 B1	3/2010	Bombard et al.
7,472,816 B2	1/2009	Holsten et al.	7,690,547 B2	4/2010	Racenet et al.
7,473,258 B2	1/2009	Clauson et al.	7,694,865 B2	4/2010	Scirica
7,481,347 B2	1/2009	Roy	7,699,205 B2	4/2010	Ivanko
7,481,348 B2	1/2009	Marczyk	7,703,653 B2	4/2010	Shah et al.
7,481,349 B2	1/2009	Holsten et al.	7,721,930 B2	5/2010	McKenna et al.
7,481,824 B2	1/2009	Gillum et al.	7,721,931 B2	5/2010	Shelton et al.
7,487,899 B2	2/2009	Shelton, IV et al.	7,721,933 B2	5/2010	Ehrenfels et al.
7,490,749 B2	2/2009	Schall et al.	7,721,935 B2	5/2010	Racenet et al.
7,494,039 B2	2/2009	Racenet et al.	7,726,537 B2	6/2010	Olson et al.
7,500,979 B2	3/2009	Hueil et al.	7,726,538 B2	6/2010	Holsten et al.
7,503,474 B2	3/2009	Hillstead et al.	7,726,539 B2	6/2010	Holsten et al.
7,506,790 B2	3/2009	Shelton, IV	7,731,072 B2	6/2010	Timm et al.
7,506,791 B2	3/2009	Omaits et al.	7,735,703 B2	6/2010	Morgan et al.
7,510,107 B2	3/2009	Timm et al.	7,740,159 B2	6/2010	Shelton et al.
7,513,408 B2	4/2009	Shelton, IV et al.	7,740,160 B2	6/2010	Viola
7,517,356 B2	4/2009	Heinrich	7,743,960 B2	6/2010	Whitman
7,537,602 B2	5/2009	Whitman	7,744,628 B2	6/2010	Viola
7,543,729 B2	6/2009	Ivanko	7,753,245 B2	7/2010	Boudreaux et al.
7,543,730 B1	6/2009	Marczyk	7,753,248 B2	7/2010	Viola
7,543,731 B2	6/2009	Green et al.	7,757,924 B2	7/2010	Gerbi et al.
7,552,854 B2	6/2009	Wixey et al.	7,757,925 B2	7/2010	Viola et al.
7,556,185 B2	7/2009	Viola	7,762,445 B2	7/2010	Heinrich et al.
7,556,186 B2	7/2009	Milliman	7,766,209 B2	8/2010	Baxter, III et al.
7,559,450 B2	7/2009	Wales et al.	7,766,210 B2	8/2010	Shelton, IV et al.
7,559,452 B2	7/2009	Wales et al.	7,766,924 B1	8/2010	Bombard et al.
7,559,453 B2	7/2009	Heinrich et al.	7,766,928 B2	8/2010	Ezzat et al.
7,559,937 B2	7/2009	de la Torre et al.	7,770,774 B2	8/2010	Mastri et al.
7,565,993 B2	7/2009	Milliman et al.	7,770,775 B2	8/2010	Shelton, IV et al.
7,568,603 B2	8/2009	Shelton, IV et al.	7,776,060 B2	8/2010	Mooradian et al.
7,568,604 B2	8/2009	Ehrenfels et al.	7,780,055 B2	8/2010	Scirica et al.
7,571,845 B2	8/2009	Viola	7,784,662 B2	8/2010	Wales et al.
7,575,144 B2	8/2009	Ortiz et al.	7,789,283 B2	9/2010	Shah
7,584,880 B2	9/2009	Racenet et al.	7,789,889 B2	9/2010	Zubik et al.
7,588,174 B2	9/2009	Holsten et al.	7,793,812 B2	9/2010	Moore et al.
7,588,175 B2	9/2009	Timm et al.	7,793,814 B2	9/2010	Racenet et al.
7,588,176 B2	9/2009	Timm et al.	7,794,475 B2	9/2010	Hess et al.
7,588,177 B2	9/2009	Racenet	7,798,385 B2	9/2010	Boyden et al.
7,597,229 B2	10/2009	Boudreaux et al.	7,798,386 B2	9/2010	Schall et al.
7,597,230 B2	10/2009	Racenet et al.	7,799,039 B2	9/2010	Shelton, IV et al.
7,600,663 B2	10/2009	Green	7,810,690 B2	10/2010	Bilotti et al.
7,604,150 B2	10/2009	Boudreaux	7,810,691 B2	10/2010	Boyden et al.
7,604,151 B2	10/2009	Hess et al.	7,810,692 B2	10/2010	Hall et al.
7,607,557 B2	10/2009	Shelton, IV et al.	7,810,693 B2	10/2010	Broehl et al.
7,611,038 B2	11/2009	Racenet et al.	7,815,090 B2	10/2010	Marczyk
7,617,961 B2	11/2009	Viola	7,815,091 B2	10/2010	Marczyk
7,624,902 B2	12/2009	Marczyk et al.	7,815,092 B2	10/2010	Whitman et al.
7,624,903 B2	12/2009	Green et al.	7,819,296 B2	10/2010	Hueil et al.
7,631,793 B2	12/2009	Rethy et al.	7,819,297 B2	10/2010	Doll et al.
7,631,794 B2	12/2009	Rethy et al.	7,819,298 B2	10/2010	Hall et al.
7,635,073 B2	12/2009	Heinrich	7,819,299 B2	10/2010	Shelton, IV et al.
7,635,074 B2	12/2009	Olson et al.	7,819,896 B2	10/2010	Racenet
7,635,373 B2	12/2009	Ortiz	7,823,760 B2	11/2010	Zemlok et al.
7,637,409 B2	12/2009	Marczyk	7,823,761 B2	11/2010	Boyden et al.
7,637,410 B2	12/2009	Marczyk	7,824,426 B2	11/2010	Racenet et al.
7,641,091 B2	1/2010	Olson et al.	7,828,186 B2	11/2010	Wales
7,641,093 B2	1/2010	Doll et al.	7,828,187 B2	11/2010	Green et al.
7,641,095 B2	1/2010	Viola	7,828,188 B2	11/2010	Jankowski
7,644,848 B2	1/2010	Swayze et al.	7,828,189 B2	11/2010	Holsten et al.
7,648,055 B2	1/2010	Marczyk	7,832,408 B2	11/2010	Shelton, IV et al.
7,651,017 B2	1/2010	Ortiz et al.	7,832,611 B2	11/2010	Boyden et al.
7,654,431 B2	2/2010	Hueil et al.	7,832,612 B2	11/2010	Baxter, III et al.
			7,837,079 B2	11/2010	Holsten et al.
			7,837,081 B2	11/2010	Holsten et al.
			7,841,503 B2	11/2010	Sonnenschein et al.
			7,845,533 B2	12/2010	Marczyk et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

7,845,534 B2	12/2010	Viola et al.	8,011,551 B2	9/2011	Marczyk et al.
7,845,535 B2	12/2010	Scircia	8,011,552 B2	9/2011	Ivanko
7,845,537 B2	12/2010	Shelton, IV et al.	8,011,553 B2	9/2011	Mastri et al.
7,845,538 B2	12/2010	Whitman	8,011,555 B2	9/2011	Tarinelli et al.
7,850,703 B2	12/2010	Bombard et al.	8,012,170 B2	9/2011	Whitman et al.
7,857,183 B2	12/2010	Shelton, IV	8,015,976 B2	9/2011	Shah
7,857,184 B2	12/2010	Viola	8,016,177 B2	9/2011	Bettuchi et al.
7,857,185 B2	12/2010	Swayze et al.	8,016,178 B2	9/2011	Olson et al.
7,857,186 B2	12/2010	Baxter, III et al.	8,020,742 B2	9/2011	Marczyk
7,861,906 B2	1/2011	Doll et al.	8,020,743 B2	9/2011	Shelton, IV
7,861,907 B2	1/2011	Green et al.	8,028,882 B2	10/2011	Viola
7,866,524 B2	1/2011	Krehel	8,028,883 B2	10/2011	Stopek
7,866,525 B2	1/2011	Scirica	8,028,884 B2	10/2011	Sniffin et al.
7,866,526 B2	1/2011	Green et al.	8,033,438 B2	10/2011	Scirica
7,866,527 B2	1/2011	Hall et al.	8,033,440 B2	10/2011	Wenchell et al.
7,866,528 B2	1/2011	Olson et al.	8,033,441 B2	10/2011	Marczyk
7,870,989 B2	1/2011	Viola et al.	8,033,442 B2	10/2011	Racenet et al.
7,886,952 B2	2/2011	Scirica et al.	8,034,077 B2	10/2011	Smith et al.
7,891,532 B2	2/2011	Mastri et al.	8,038,044 B2	10/2011	Viola
7,891,533 B2	2/2011	Green et al.	8,038,045 B2	10/2011	Bettuchi et al.
7,891,534 B2	2/2011	Wenchell et al.	8,052,024 B2	11/2011	Viola et al.
7,896,214 B2	3/2011	Farascioni	8,056,787 B2	11/2011	Boudreaux et al.
7,900,805 B2	3/2011	Shelton, IV et al.	8,056,788 B2	11/2011	Mastri et al.
7,901,416 B2	3/2011	Nolan et al.	8,056,791 B2	11/2011	Whitman
7,905,380 B2	3/2011	Shelton, IV et al.	8,061,577 B2	11/2011	Racenet et al.
7,905,381 B2	3/2011	Baxter, III et al.	8,066,166 B2	11/2011	Demmy et al.
7,909,039 B2	3/2011	Hur	8,070,033 B2	12/2011	Milliman et al.
7,909,220 B2	3/2011	Viola	8,070,035 B2	12/2011	Holsten et al.
7,909,221 B2	3/2011	Viola et al.	8,074,858 B2	12/2011	Marczyk
7,909,224 B2	3/2011	Prommersberger	8,074,859 B2	12/2011	Kostrzewski
7,913,891 B2	3/2011	Doll et al.	8,074,862 B2	12/2011	Shah
7,913,893 B2	3/2011	Mastri et al.	8,083,118 B2	12/2011	Milliman et al.
7,914,543 B2	3/2011	Roth et al.	8,083,119 B2	12/2011	Prommersberger
7,918,230 B2	4/2011	Whitman et al.	8,083,120 B2	12/2011	Shelton et al.
7,918,276 B2	4/2011	Guignard et al.	8,087,563 B2	1/2012	Milliman et al.
7,922,061 B2	4/2011	Shelton, IV et al.	8,091,753 B2	1/2012	Viola
7,922,063 B2	4/2011	Zemlok et al.	8,091,754 B2	1/2012	Ehrenfels et al.
7,922,064 B2	4/2011	Boyden et al.	8,091,756 B2	1/2012	Viola
7,926,691 B2	4/2011	Viola et al.	8,096,459 B2	1/2012	Ortiz et al.
7,926,692 B2	4/2011	Racenet et al.	8,096,460 B2	1/2012	Blier et al.
7,934,628 B2	5/2011	Wenchell et al.	8,100,309 B2	1/2012	Marczyk
7,934,630 B2	5/2011	Shelton, IV et al.	8,100,310 B2	1/2012	Zemlok
7,934,631 B2	5/2011	Balbierz et al.	8,113,406 B2	2/2012	Holsten et al.
7,942,300 B2	5/2011	Rethy et al.	8,113,407 B2	2/2012	Holsten et al.
7,942,303 B2	5/2011	Shah	8,113,408 B2	2/2012	Wenchell et al.
7,950,560 B2	5/2011	Zemlok et al.	8,113,409 B2	2/2012	Cohen et al.
7,950,561 B2	5/2011	Aranyi	8,113,410 B2	2/2012	Hall et al.
7,950,562 B2	5/2011	Beardsley et al.	8,123,101 B2	2/2012	Racenet et al.
7,954,682 B2	6/2011	Giordano et al.	8,127,975 B2	3/2012	Olson et al.
7,954,683 B1	6/2011	Knodel et al.	8,127,976 B2	3/2012	Scirica et al.
7,954,684 B2	6/2011	Boudreaux	8,132,703 B2	3/2012	Milliman et al.
7,954,685 B2	6/2011	Viola	8,132,705 B2	3/2012	Viola et al.
7,954,686 B2	6/2011	Baxter, III et al.	8,132,706 B2	3/2012	Marczyk et al.
7,954,687 B2	6/2011	Zemlok et al.	8,136,713 B2	3/2012	Hathaway et al.
7,959,051 B2	6/2011	Smith et al.	8,141,762 B2	3/2012	Bedi et al.
7,963,431 B2	6/2011	Scirica	8,152,041 B2	4/2012	Kostrzewski
7,963,432 B2	6/2011	Knodel et al.	8,157,148 B2	4/2012	Scirica
7,963,433 B2	6/2011	Whitman et al.	8,157,151 B2	4/2012	Ingmanson et al.
7,967,178 B2	6/2011	Scirica et al.	8,167,185 B2	5/2012	Shelton, IV et al.
7,967,179 B2	6/2011	Olson et al.	8,167,186 B2	5/2012	Racenet et al.
7,967,180 B2	6/2011	Scirica	8,172,121 B2	5/2012	Krehel
7,975,894 B2	7/2011	Boyden et al.	8,172,124 B2	5/2012	Shelton, IV et al.
7,980,443 B2	7/2011	Scheib et al.	8,181,837 B2	5/2012	Roy
7,988,026 B2	8/2011	Knodel et al.	8,186,555 B2	5/2012	Shelton, IV et al.
7,988,027 B2	8/2011	Olson et al.	8,186,558 B2	5/2012	Sapienza
7,988,028 B2	8/2011	Farascioni et al.	8,186,560 B2	5/2012	Hess et al.
7,992,758 B2	8/2011	Whitman et al.	8,196,795 B2	6/2012	Moore et al.
7,997,468 B2	8/2011	Farascioni	8,196,796 B2	6/2012	Shelton, IV et al.
7,997,469 B2	8/2011	Olson et al.	8,205,619 B2	6/2012	Shah et al.
8,002,795 B2	8/2011	Beetel	8,205,780 B2	6/2012	Sorrentino et al.
8,006,885 B2	8/2011	Marczyk	8,205,781 B2	6/2012	Baxter, III et al.
8,006,887 B2	8/2011	Marczyk	8,210,416 B2	7/2012	Milliman et al.
8,007,505 B2	8/2011	Weller et al.	8,216,236 B2	7/2012	Heinrich et al.
8,007,513 B2	8/2011	Nalagatla et al.	8,220,688 B2	7/2012	Laurent et al.
8,011,550 B2	9/2011	Aranyi et al.	8,220,690 B2	7/2012	Hess et al.
			8,225,979 B2	7/2012	Farascioni et al.
			8,231,040 B2	7/2012	Zemlok et al.
			8,231,041 B2	7/2012	Marczyk et al.
			8,235,272 B2	8/2012	Nicholas et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

8,236,010	B2	8/2012	Ortiz et al.	2009/0209990	A1	8/2009	Yates et al.
8,241,322	B2	8/2012	Whitman et al.	2009/0236395	A1	9/2009	Scirica
8,245,897	B2	8/2012	Tzakis et al.	2009/0242610	A1	10/2009	Shelton, IV et al.
8,245,898	B2	8/2012	Smith et al.	2009/0255974	A1	10/2009	Viola
8,245,899	B2	8/2012	Swensgard et al.	2009/0272787	A1	11/2009	Scirica
8,252,009	B2	8/2012	Weller et al.	2009/0277946	A1	11/2009	Marczyk
8,256,656	B2 *	9/2012	Milliman et al. 227/180.1	2009/0277949	A1	11/2009	Viola et al.
8,267,300	B2	9/2012	Boudreaux	2009/0283568	A1	11/2009	Racenet et al.
8,272,554	B2	9/2012	Whitman et al.	2009/0306708	A1	12/2009	Shah
8,292,152	B2 *	10/2012	Milliman et al. 227/175.1	2009/0308907	A1	12/2009	Nalagatla et al.
8,342,377	B2 *	1/2013	Milliman et al. 227/175.2	2010/0012703	A1	1/2010	Calabrese et al.
2004/0108357	A1	6/2004	Milliman	2010/0012704	A1	1/2010	Racenet et al.
2004/0199180	A1	10/2004	Knodel et al.	2010/0069942	A1	3/2010	Shelton, IV et al.
2004/0199181	A1	10/2004	Knodel et al.	2010/0072254	A1	3/2010	Aranyi et al.
2004/0232201	A1	11/2004	Wenchell	2010/0076429	A1	3/2010	Heinrich
2004/0243151	A1	12/2004	Demmy	2010/0076459	A1	3/2010	Farascioni
2004/0267310	A1	12/2004	Racenet	2010/0089970	A1	4/2010	Smith
2005/0103819	A1	5/2005	Racenet	2010/0127041	A1	5/2010	Morgan et al.
2005/0119669	A1	6/2005	Demmy	2010/0127042	A1	5/2010	Shelton, IV
2005/0189397	A1	9/2005	Jankowski	2010/0133317	A1	6/2010	Shelton, IV et al.
2005/0216055	A1	9/2005	Scirica et al.	2010/0133318	A1	6/2010	Boudreaux
2006/0049229	A1	3/2006	Milliman et al.	2010/0147921	A1	6/2010	Olson
2006/0180634	A1	8/2006	Shelton, IV et al.	2010/0147922	A1	6/2010	Olson
2006/0289602	A1	12/2006	Wales et al.	2010/0155453	A1	6/2010	Bombard et al.
2007/0027469	A1	2/2007	Smith et al.	2010/0170931	A1	7/2010	Viola
2007/0073341	A1	3/2007	Smith et al.	2010/0193566	A1	8/2010	Scheib et al.
2007/0084897	A1	4/2007	Shelton, IV et al.	2010/0224668	A1	9/2010	Fontayne et al.
2007/0084899	A1	4/2007	Taylor	2010/0230468	A1	9/2010	Viola
2007/0102472	A1	5/2007	Shelton, IV	2010/0237130	A1	9/2010	Scirica
2007/0106317	A1	5/2007	Shelton, IV	2010/0243709	A1	9/2010	Hess et al.
2007/0119901	A1	5/2007	Ehrenfels et al.	2010/0249802	A1	9/2010	May et al.
2007/0145096	A1	6/2007	Viola et al.	2010/0252611	A1	10/2010	Ezzat et al.
2007/0170225	A1	7/2007	Shelton, IV et al.	2010/0252612	A1	10/2010	Viola
2007/0175949	A1	8/2007	Shelton, IV et al.	2010/0264192	A1	10/2010	Marczyk
2007/0175950	A1	8/2007	Shelton, IV et al.	2010/0264193	A1	10/2010	Huang et al.
2007/0175951	A1	8/2007	Shelton, IV et al.	2010/0264194	A1	10/2010	Huang et al.
2007/0175955	A1	8/2007	Shelton, IV et al.	2010/0294828	A1	11/2010	Bindra et al.
2007/0179528	A1	8/2007	Soltz et al.	2010/0294829	A1	11/2010	Giordano et al.
2007/0194079	A1	8/2007	Hueil et al.	2010/0301095	A1	12/2010	Shelton, IV et al.
2007/0194081	A1	8/2007	Hueil et al.	2010/0305552	A1	12/2010	Shelton, IV et al.
2007/0194082	A1	8/2007	Morgan et al.	2010/0308100	A1	12/2010	Boudreaux
2007/0221700	A1	9/2007	Ortiz et al.	2010/0320252	A1	12/2010	Viola et al.
2007/0295780	A1	12/2007	Shelton et al.	2010/0320254	A1	12/2010	Zemlok et al.
2008/0029570	A1	2/2008	Shelton et al.	2011/0006099	A1	1/2011	Hall et al.
2008/0029573	A1	2/2008	Shelton et al.	2011/0006101	A1	1/2011	Hall et al.
2008/0029574	A1	2/2008	Shelton et al.	2011/0006103	A1	1/2011	Laurent et al.
2008/0029575	A1	2/2008	Shelton et al.	2011/0011914	A1	1/2011	Baxter, III et al.
2008/0078800	A1	4/2008	Hess et al.	2011/0011915	A1	1/2011	Shelton, IV
2008/0078802	A1	4/2008	Hess et al.	2011/0017801	A1	1/2011	Zemlok et al.
2008/0078803	A1	4/2008	Shelton et al.	2011/0024477	A1	2/2011	Hall
2008/0078804	A1	4/2008	Shelton et al.	2011/0024478	A1	2/2011	Shelton, IV
2008/0078806	A1	4/2008	Omaits et al.	2011/0036887	A1	2/2011	Zemlok et al.
2008/0078808	A1	4/2008	Hess et al.	2011/0036888	A1	2/2011	Pribanic et al.
2008/0110961	A1	5/2008	Voegele et al.	2011/0036890	A1	2/2011	Ma
2008/0149685	A1	6/2008	Smith et al.	2011/0036891	A1	2/2011	Zemlok et al.
2008/0169328	A1	7/2008	Shelton	2011/0036892	A1	2/2011	Marczyk et al.
2008/0169329	A1	7/2008	Shelton et al.	2011/0036895	A1	2/2011	Marczyk et al.
2008/0169330	A1	7/2008	Shelton et al.	2011/0042439	A1	2/2011	Johnson et al.
2008/0169331	A1	7/2008	Shelton et al.	2011/0042441	A1	2/2011	Shelton, IV et al.
2008/0169332	A1	7/2008	Shelton et al.	2011/0062213	A1	3/2011	Scirica et al.
2008/0169333	A1	7/2008	Shelton et al.	2011/0068145	A1	3/2011	Bedi et al.
2008/0287987	A1	11/2008	Boyden et al.	2011/0068148	A1	3/2011	Hall et al.
2008/0296344	A1	12/2008	Cropper et al.	2011/0084114	A1	4/2011	Marczyk et al.
2008/0296346	A1	12/2008	Shelton, IV et al.	2011/0084115	A1	4/2011	Bedi et al.
2008/0308602	A1	12/2008	Timm et al.	2011/0087276	A1	4/2011	Bedi et al.
2008/0308603	A1	12/2008	Shelton, IV et al.	2011/0089221	A1	4/2011	Masiakos et al.
2009/0001121	A1	1/2009	Hess et al.	2011/0095067	A1	4/2011	Ohdaira
2009/0001124	A1	1/2009	Hess et al.	2011/0101067	A1	5/2011	Johnson et al.
2009/0001130	A1	1/2009	Hess et al.	2011/0101069	A1	5/2011	Bombard et al.
2009/0005808	A1	1/2009	Hess et al.	2011/0108603	A1	5/2011	Racenet et al.
2009/0065549	A1	3/2009	Viola	2011/0114702	A1	5/2011	Farascioni
2009/0078739	A1	3/2009	Viola	2011/0121049	A1	5/2011	Malinouskas et al.
2009/0090763	A1	4/2009	Zemlok et al.	2011/0132961	A1	6/2011	Whitman et al.
2009/0090766	A1	4/2009	Knodel	2011/0132963	A1	6/2011	Giordano et al.
2009/0209946	A1	8/2009	Swayze et al.	2011/0132964	A1	6/2011	Weisenburgh, II et al.
				2011/0132965	A1	6/2011	Moore et al.
				2011/0139851	A1	6/2011	McCuen
				2011/0144640	A1	6/2011	Heinrich et al.
				2011/0147433	A1	6/2011	Shelton, IV et al.

(56)

References Cited

U.S. PATENT DOCUMENTS

2011/0147434	A1	6/2011	Hueil et al.
2011/0155781	A1	6/2011	Swensgard et al.
2011/0155784	A1	6/2011	Shelton, IV et al.
2011/0155786	A1	6/2011	Shelton, IV
2011/0155787	A1	6/2011	Baxter, III et al.
2011/0155788	A1	6/2011	Hillstead et al.
2011/0163146	A1	7/2011	Ortiz et al.
2011/0163147	A1	7/2011	Laurent et al.
2011/0163149	A1	7/2011	Viola
2011/0163150	A1	7/2011	Farascioni
2011/0168757	A1	7/2011	Viola et al.
2011/0168760	A1	7/2011	Viola et al.
2011/0174862	A1	7/2011	Shelton, IV et al.
2011/0174863	A1	7/2011	Shelton, IV et al.
2011/0180585	A1	7/2011	Czernik et al.
2011/0186614	A1	8/2011	Kasvikis
2011/0192881	A1	8/2011	Balbierz et al.
2011/0192882	A1	8/2011	Hess et al.
2011/0192883	A1	8/2011	Whitman et al.
2011/0198385	A1	8/2011	Whitman et al.
2011/0198386	A1	8/2011	Viola
2011/0204119	A1	8/2011	McCuen
2011/0204120	A1	8/2011	Crainich
2011/0210157	A1	9/2011	Knodel et al.
2011/0215132	A1	9/2011	Aranyi et al.
2011/0215133	A1	9/2011	Aranyi
2011/0226837	A1	9/2011	Baxter, III et al.
2011/0233258	A1	9/2011	Boudreaux
2011/0233259	A1	9/2011	Olson
2011/0240713	A1	10/2011	Scirica et al.
2011/0240714	A1	10/2011	Whitman et al.
2011/0253765	A1	10/2011	Nicholas et al.
2011/0257679	A1	10/2011	Ishitsuki et al.

FOREIGN PATENT DOCUMENTS

DE	2903159	1/1980
DE	3114135	10/1982
DE	4213426	10/1992
DE	4300307	7/1994
EP	0041022	12/1981
EP	0136950	4/1985
EP	0140552	5/1985
EP	0156774	10/1985
EP	0216532	4/1987
EP	0220029	4/1987
EP	0213817	11/1987
EP	0273468	7/1988
EP	0324166	7/1989
EP	0324635	7/1989
EP	0324637	7/1989
EP	0324638	7/1989
EP	0369324	5/1990
EP	0373762	6/1990
EP	0380025	8/1990
EP	0399701	11/1990
EP	0449394	10/1991
EP	0484677	5/1992

EP	0489436	6/1992
EP	0503662	9/1992
EP	0514139	11/1992
EP	0536903	4/1993
EP	0537572	4/1993
EP	0539762	5/1993
EP	0545029	6/1993
EP	0552050	7/1993
EP	0552423	7/1993
EP	0579038	1/1994
EP	0589306	3/1994
EP	0591946	4/1994
EP	0592243	4/1994
EP	0592244	4/1994
EP	0593920	4/1994
EP	0598202	5/1994
EP	0598579	5/1994
EP	0600182	6/1994
EP	0621006	10/1994
EP	0621009	10/1994
EP	0656188	6/1995
EP	0365153	8/1995
EP	0666057	8/1995
EP	0674876	10/1995
EP	0699418	3/1996
EP	0 705 570 A1	4/1996
EP	0705571	4/1996
EP	0760230	3/1997
EP	0 807 409	11/1997
FR	2542188	9/1984
FR	2660851	10/1991
FR	2681775	10/1991
GB	1352554	4/1971
GB	1452185	10/1976
GB	1555455	11/1979
GB	2048685	12/1980
GB	2070499	9/1981
GB	2141066	12/1984
GB	2165559	4/1986
JP	51-149985	6/1975
SU	659146	4/1979
SU	728848	5/1980
SU	980703	12/1982
SU	990220	1/1983
WO	WO 8302247	7/1983
WO	WO 89/10094	11/1989
WO	WO 9210976	7/1992
WO	WO 9308754	5/1993
WO	WO 9314706	8/1993

OTHER PUBLICATIONS

- EP Search Report EP 90167613.0-2320 date of completion Mar. 11, 2010.
- European Search Report EP 08252877 dated Jun. 23, 2009.
- European Search Report EP 09167613.0 dated Mar. 17, 2010.
- European Search Report EP 09175507.4 dated Jan. 20, 2010.
- European Search Report EP 10175047.9 dated Nov. 25, 2010.
- European Search Report EP 10175056.0 dated Jul. 10.2012.
- European Search Report EP 10185767.0 dated Mar. 3. 2011.

* cited by examiner

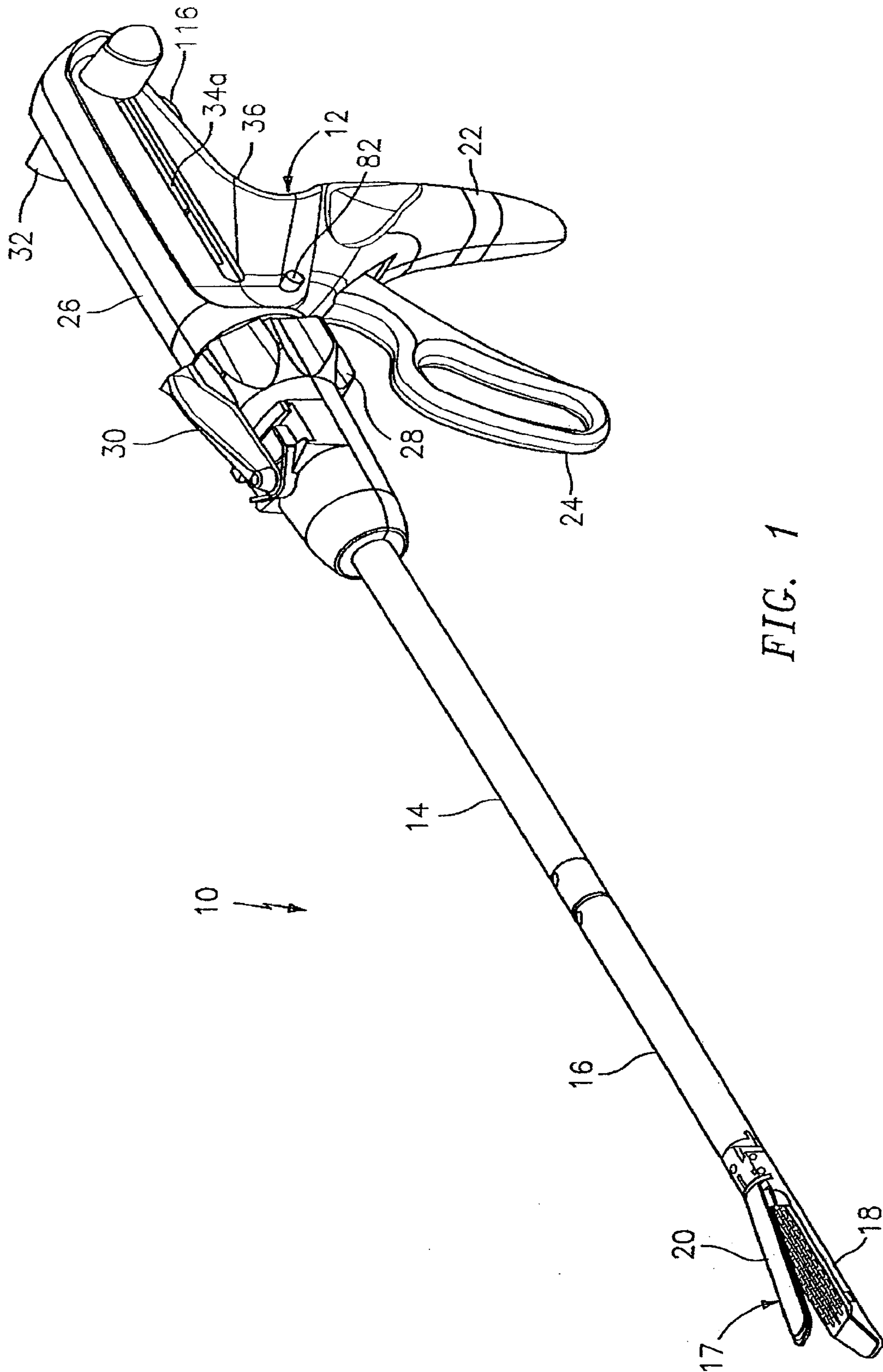


FIG. 1

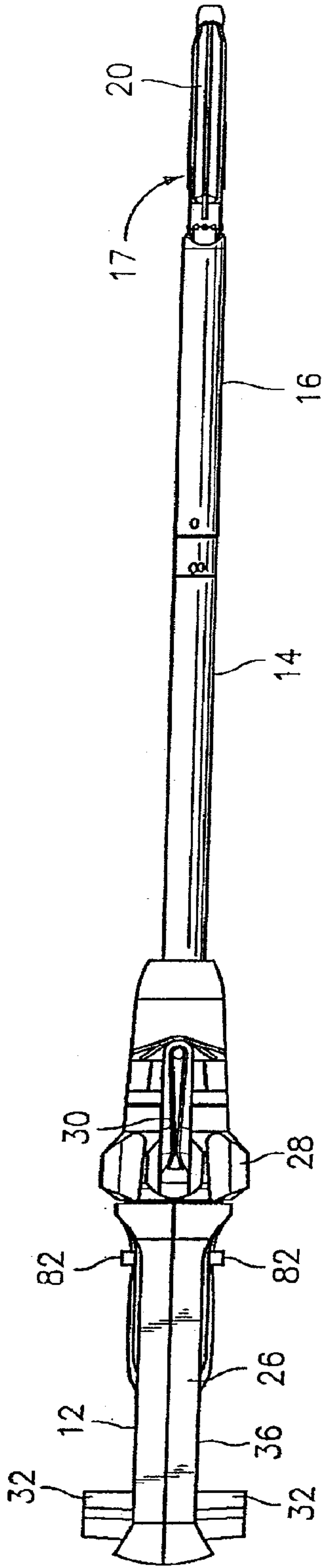


FIG. 2

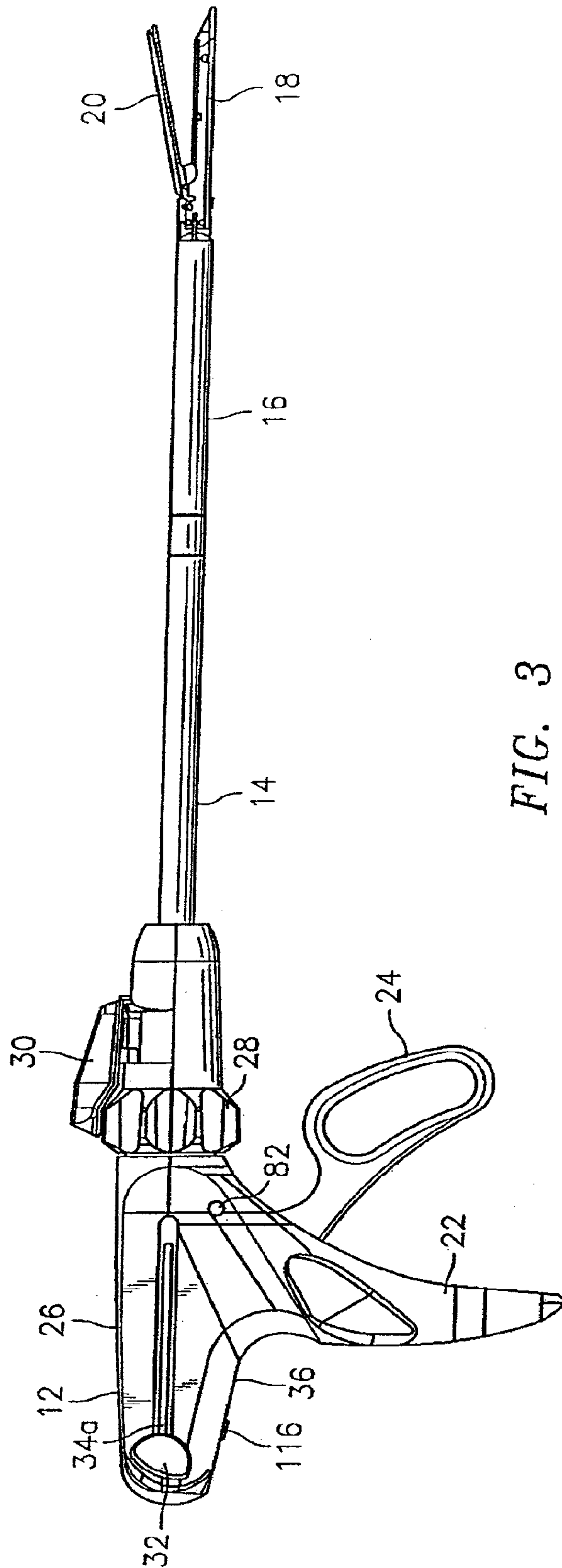


FIG. 3

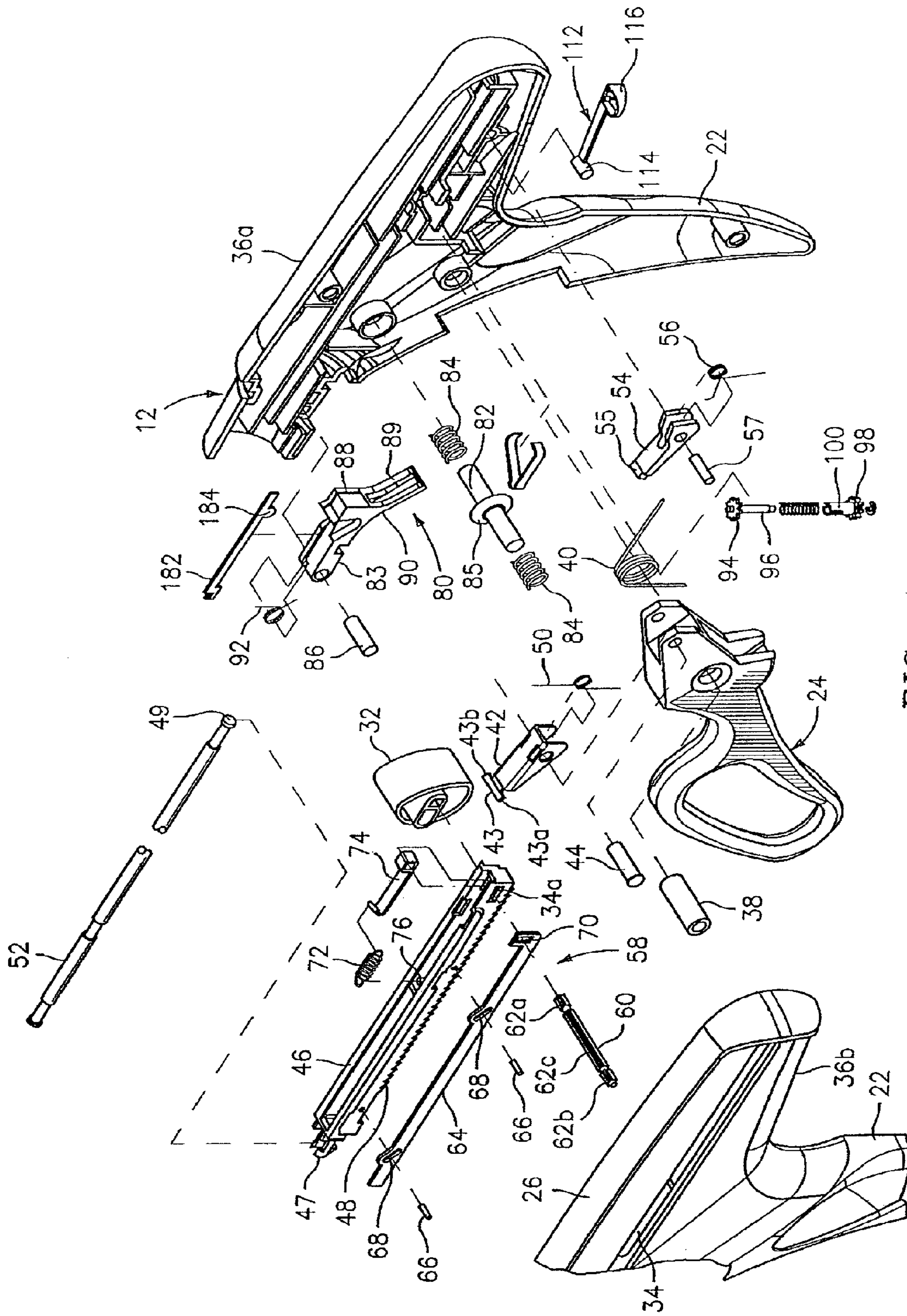


FIG. 4

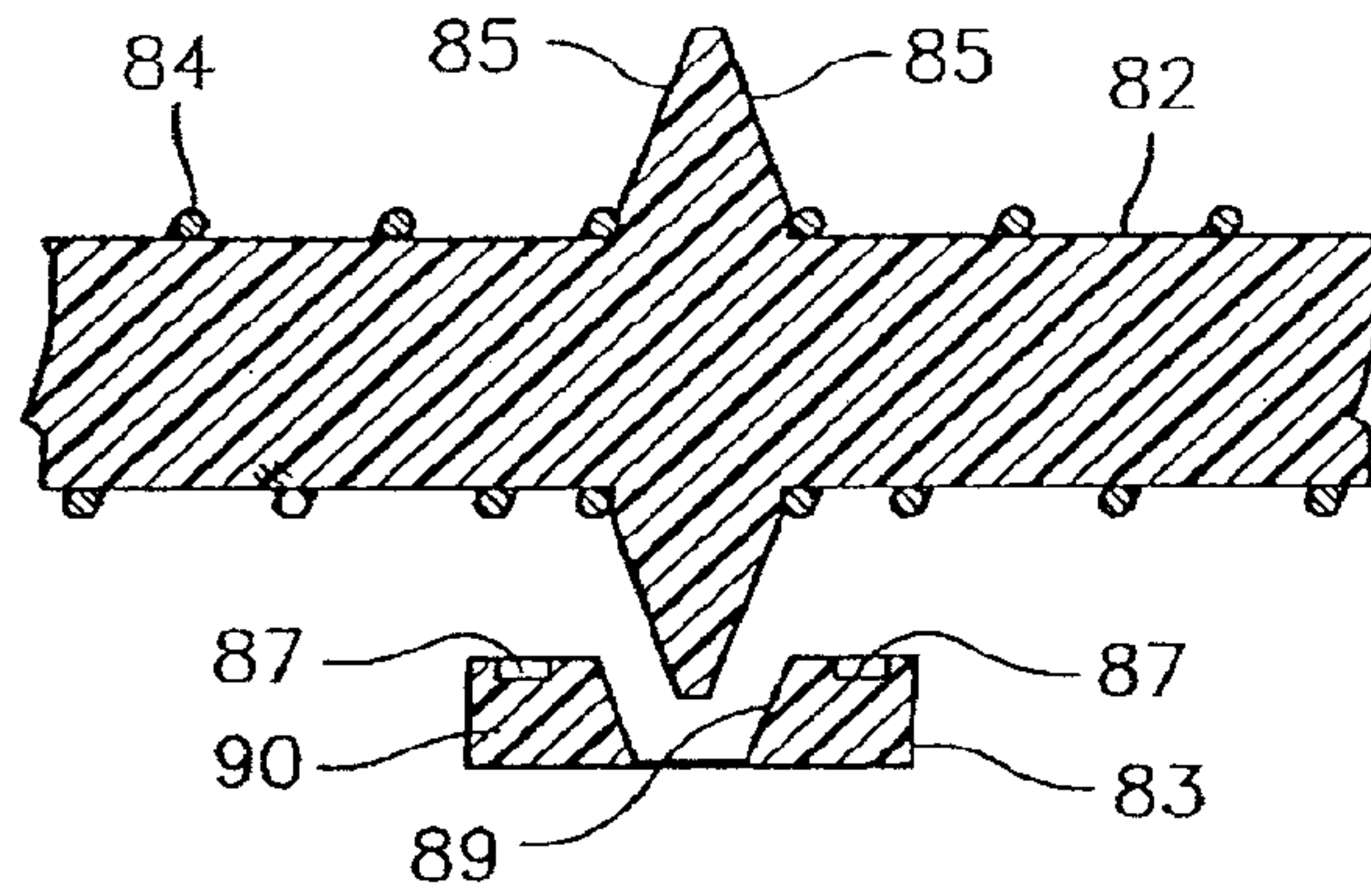


FIG. 5

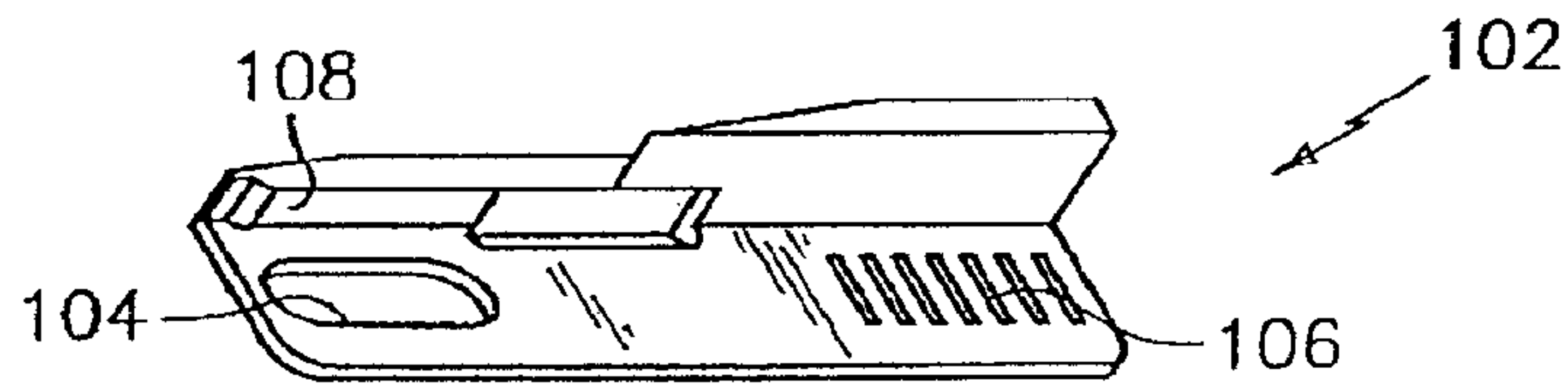


FIG. 6

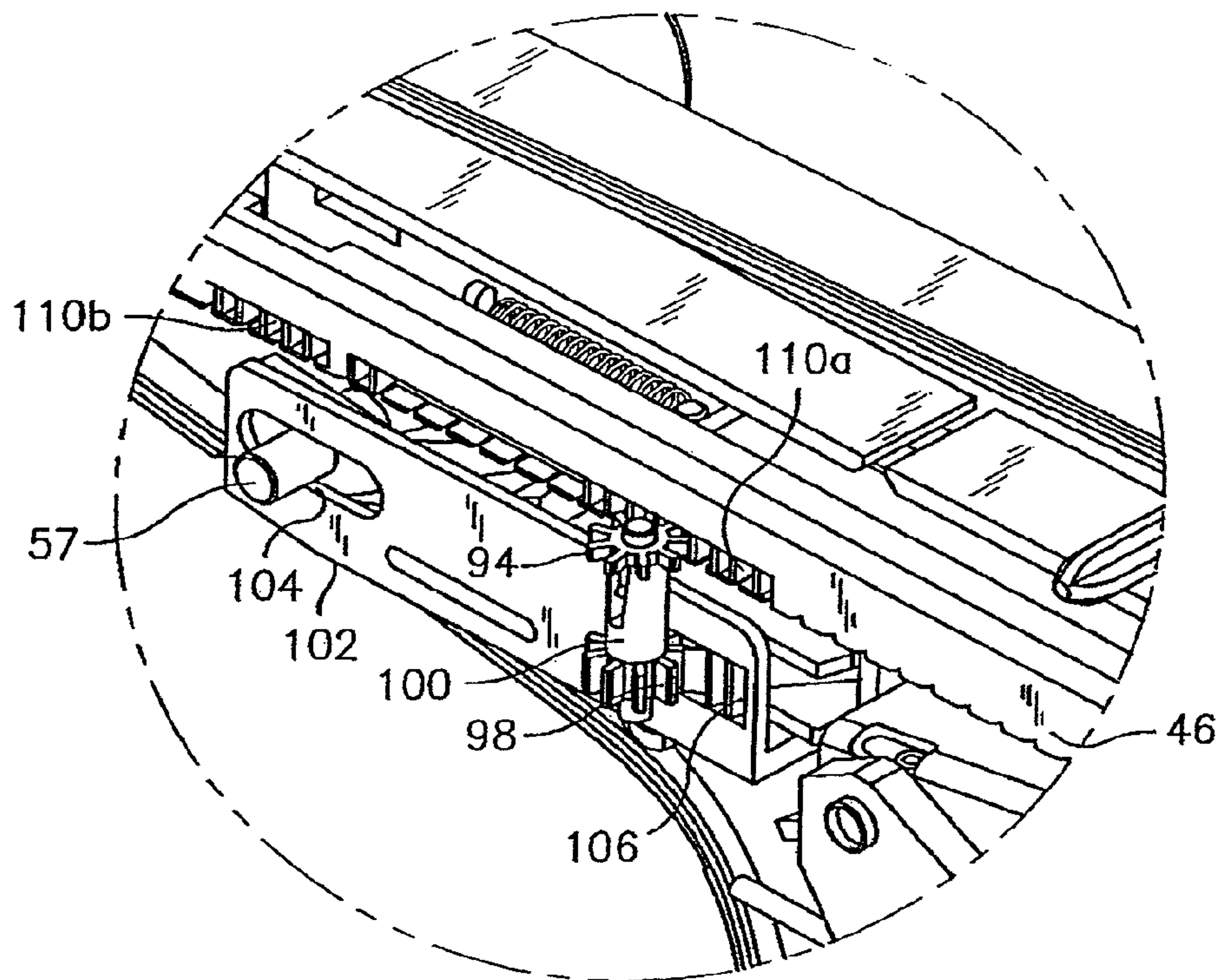
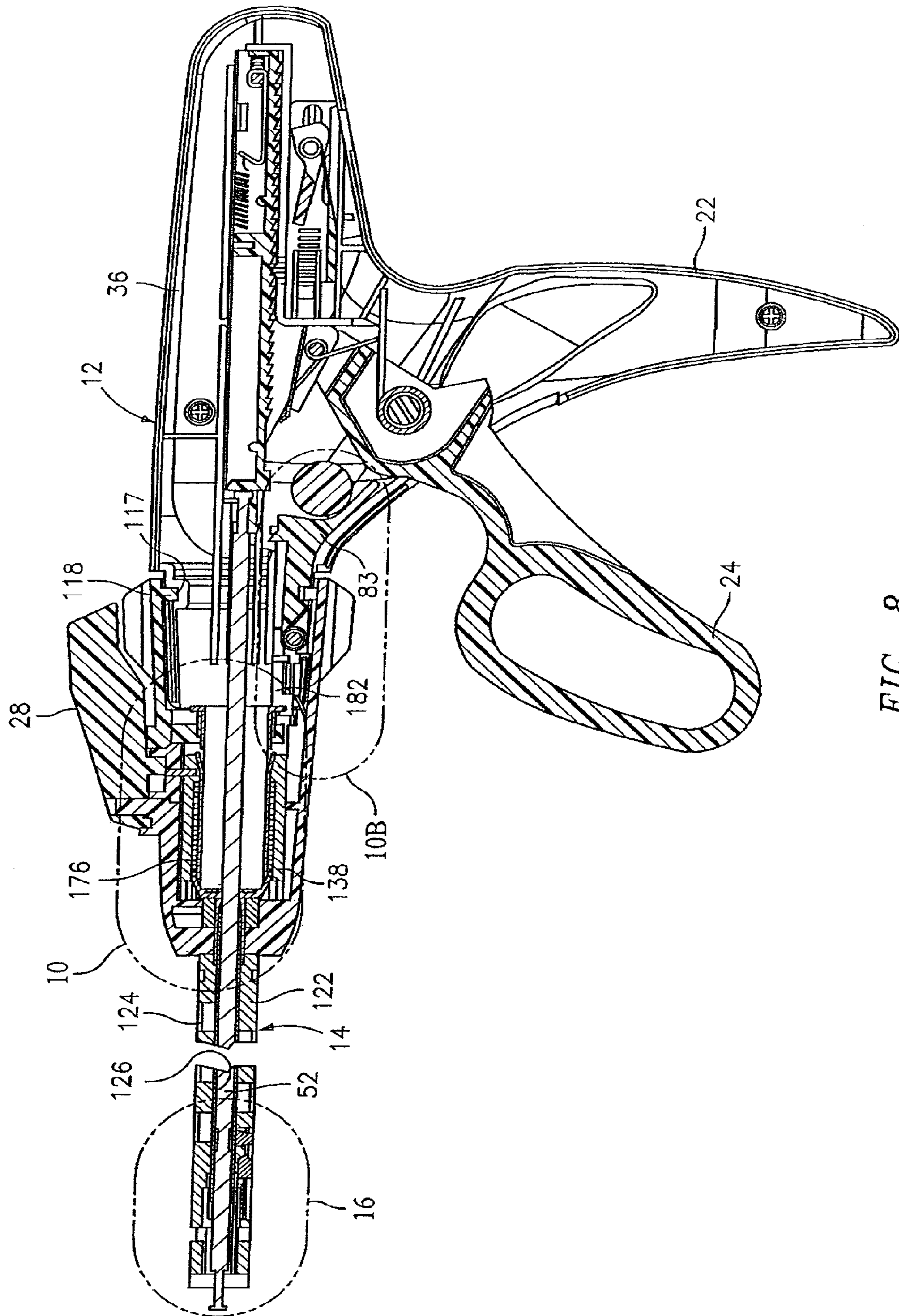


FIG. 7



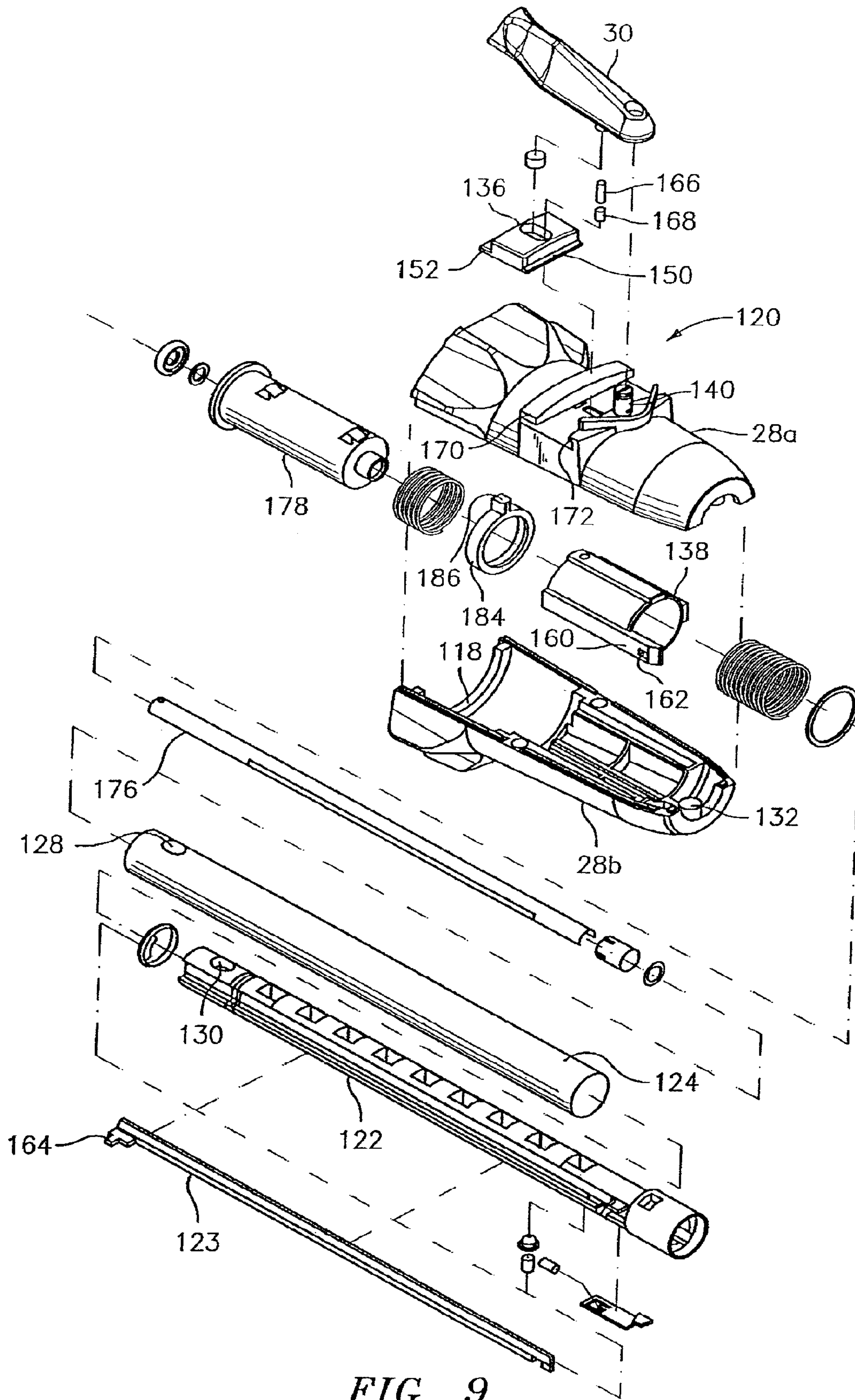


FIG. 9

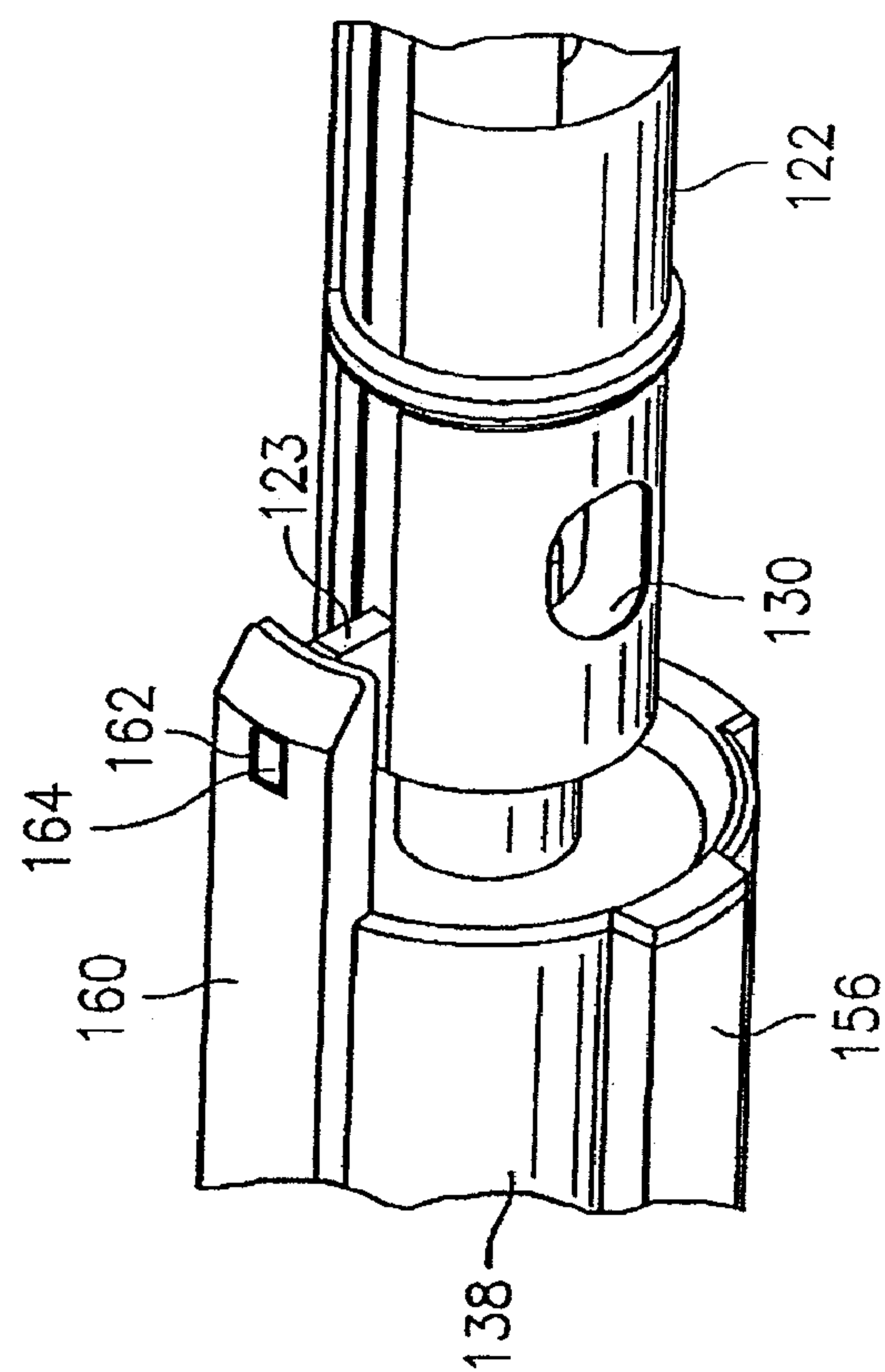


FIG. 10A

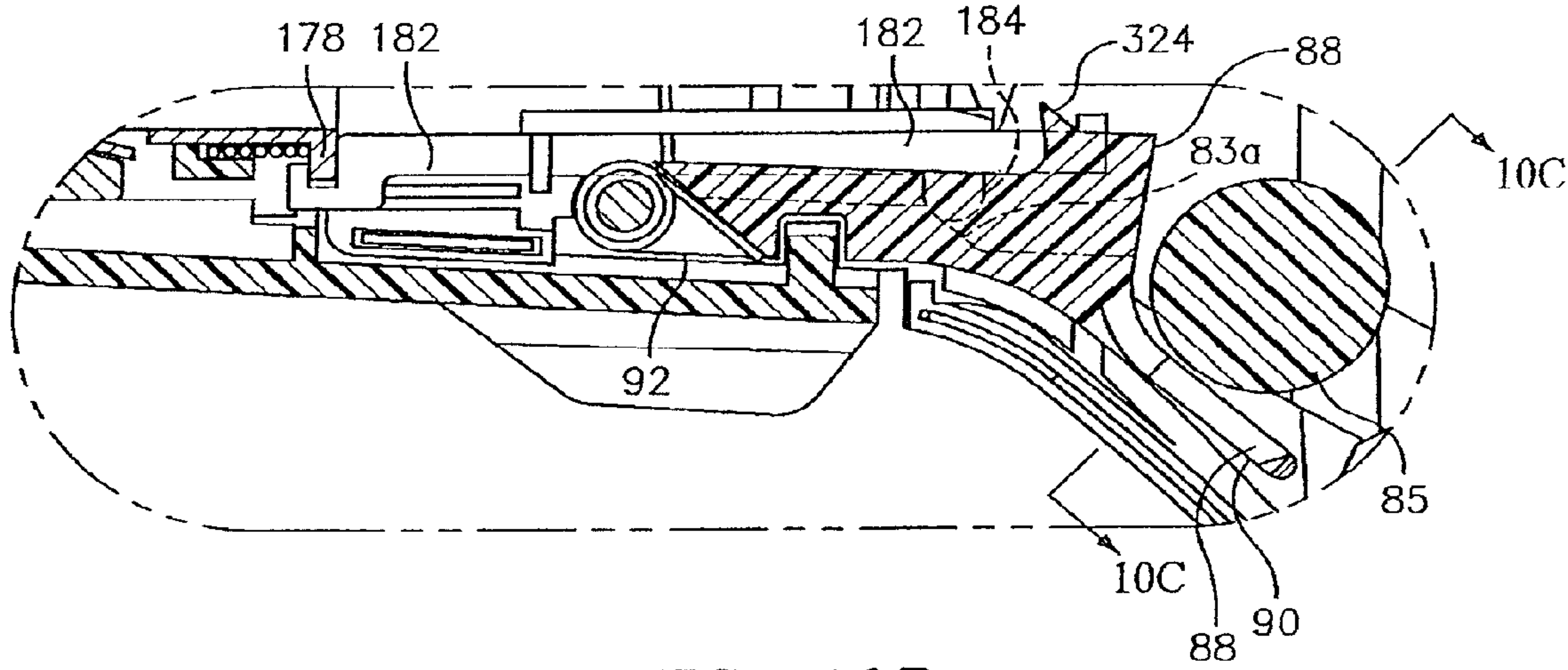


FIG. 10B

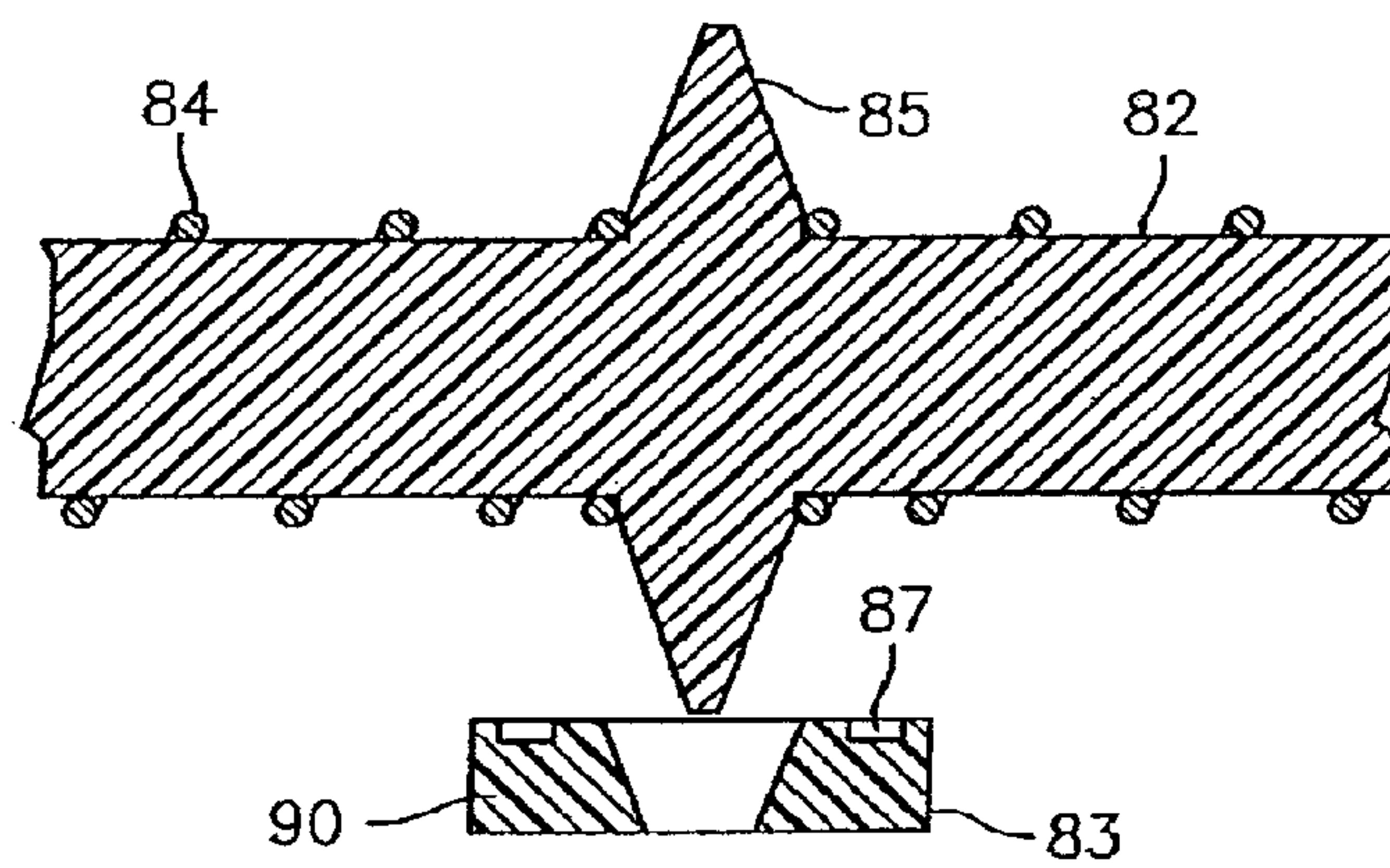


FIG. 10C

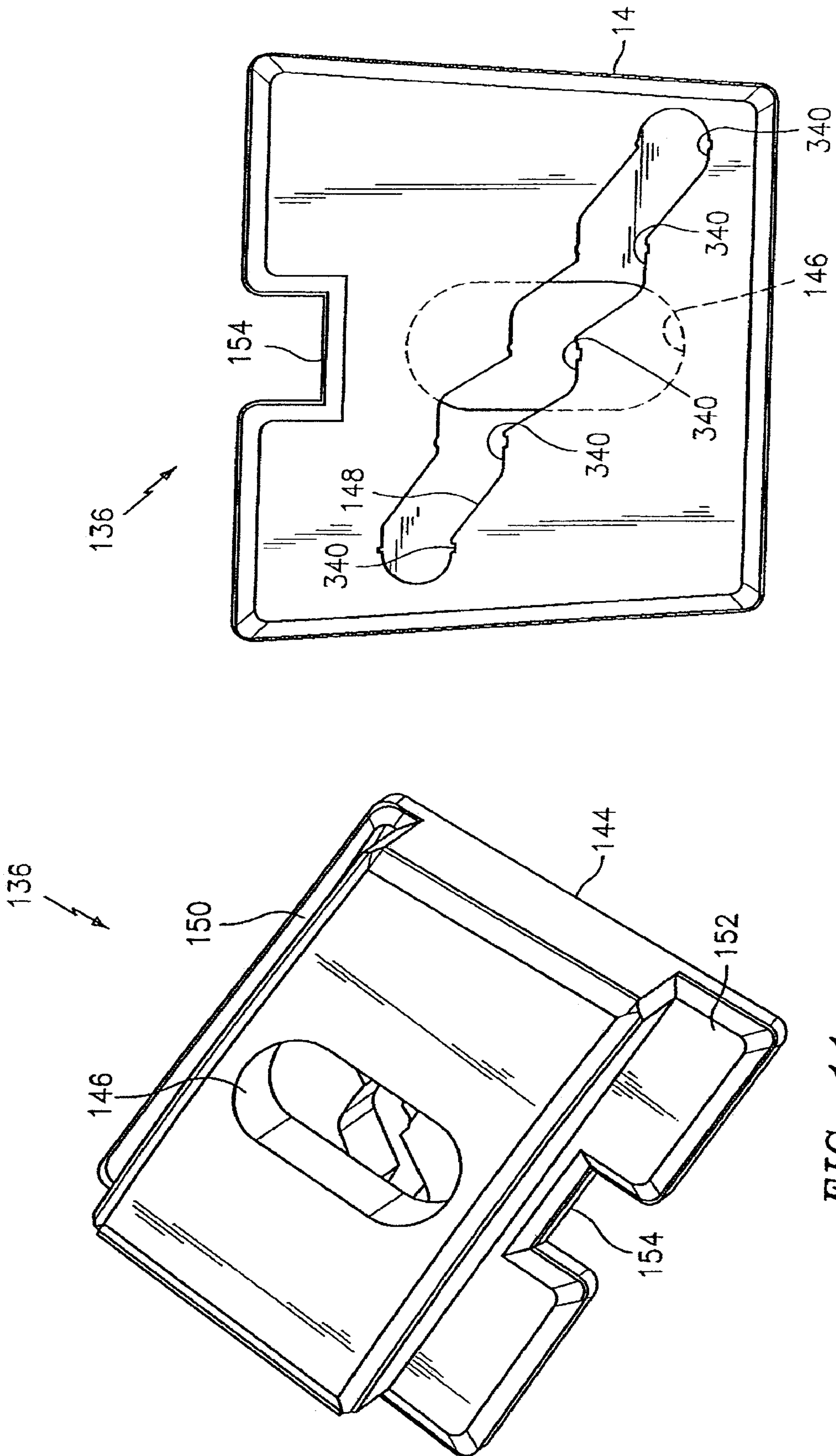


FIG. 12

FIG. 11

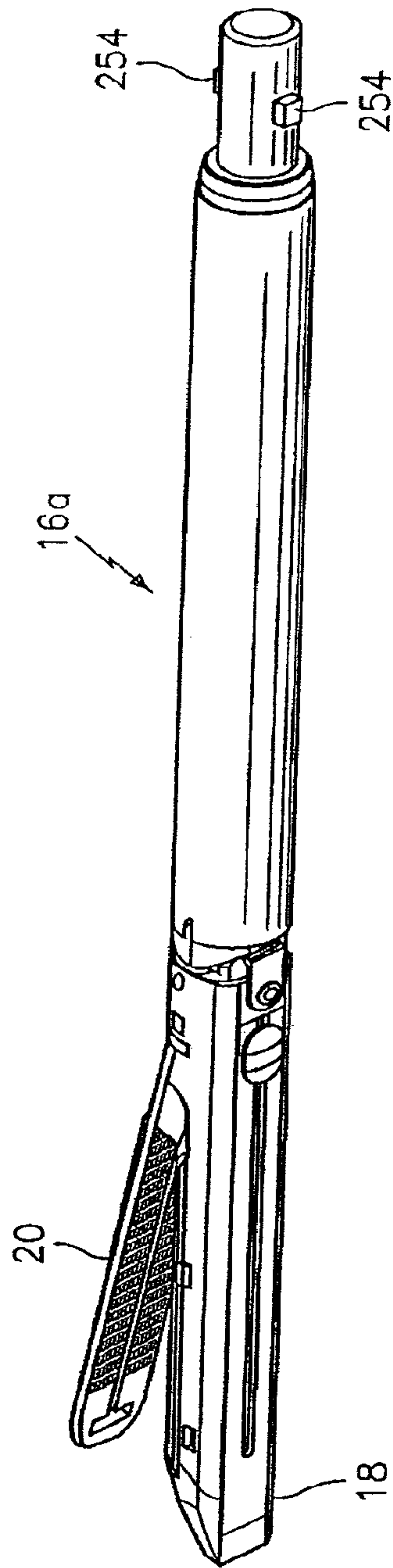


FIG. 12A

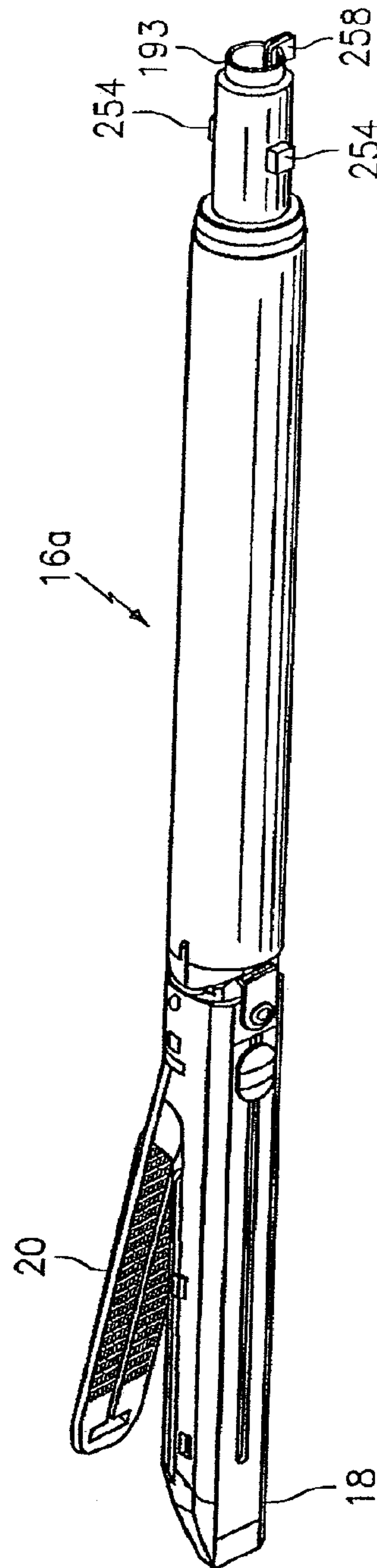


FIG. 12B

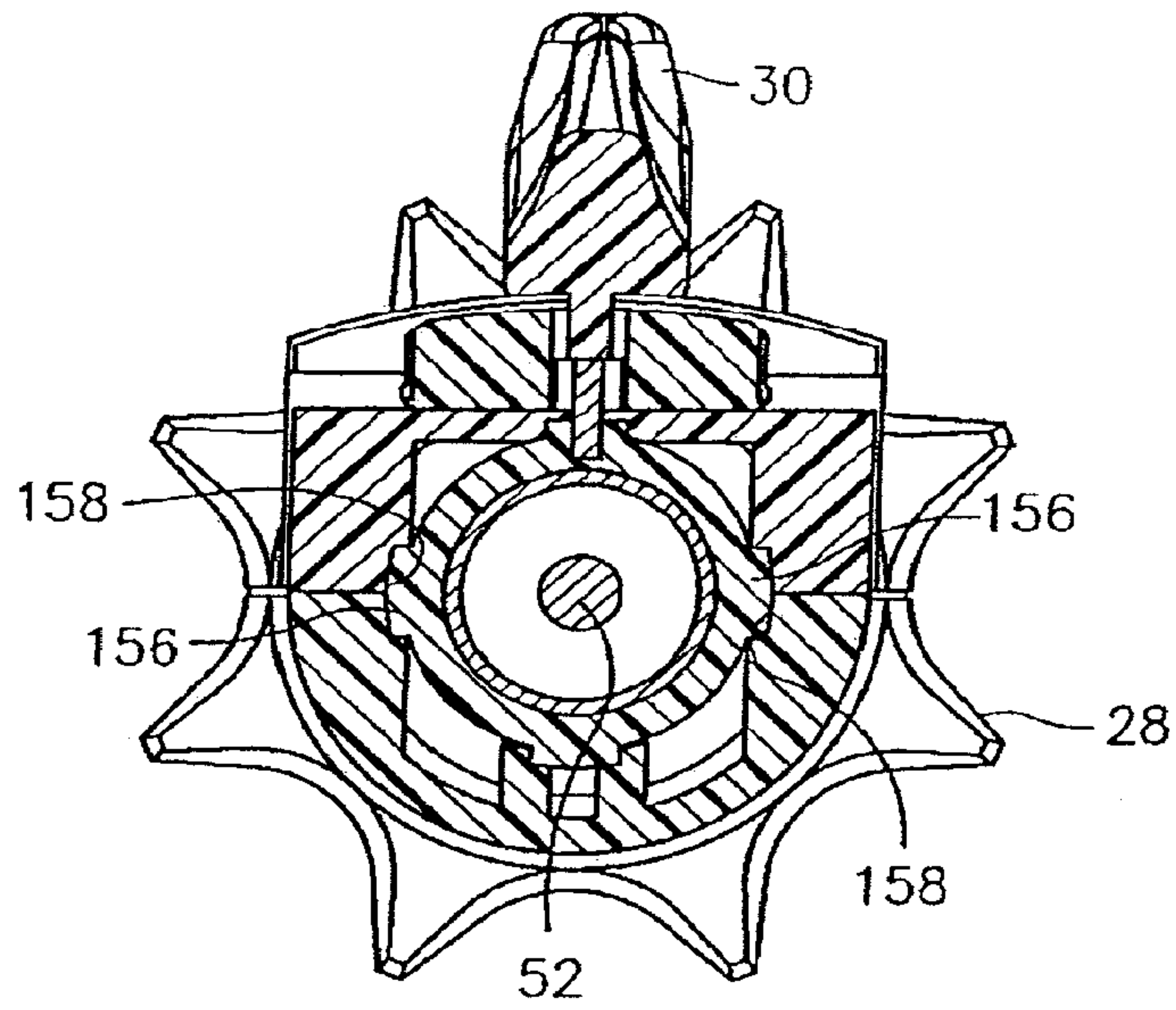


FIG. 13

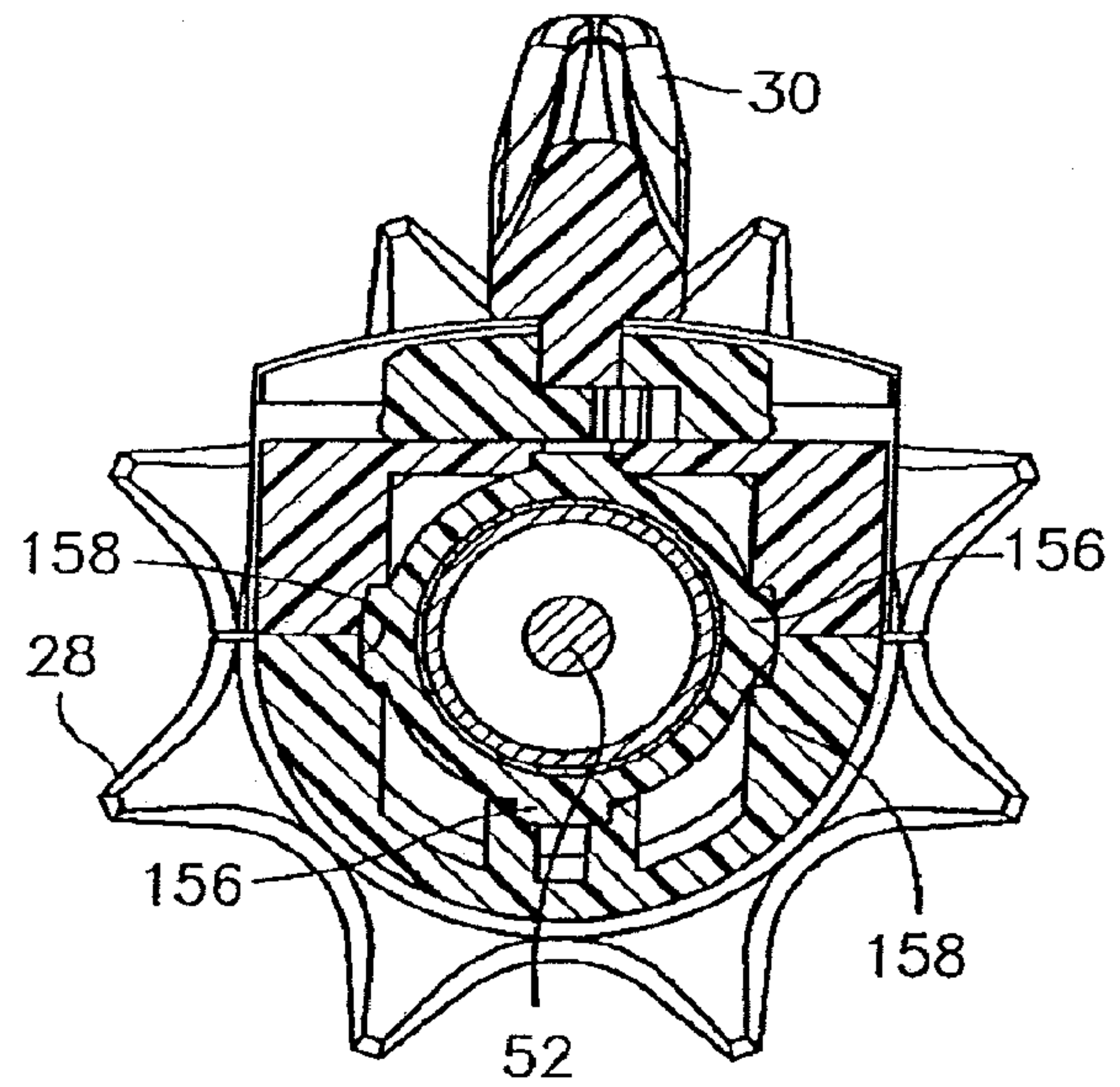


FIG. 14

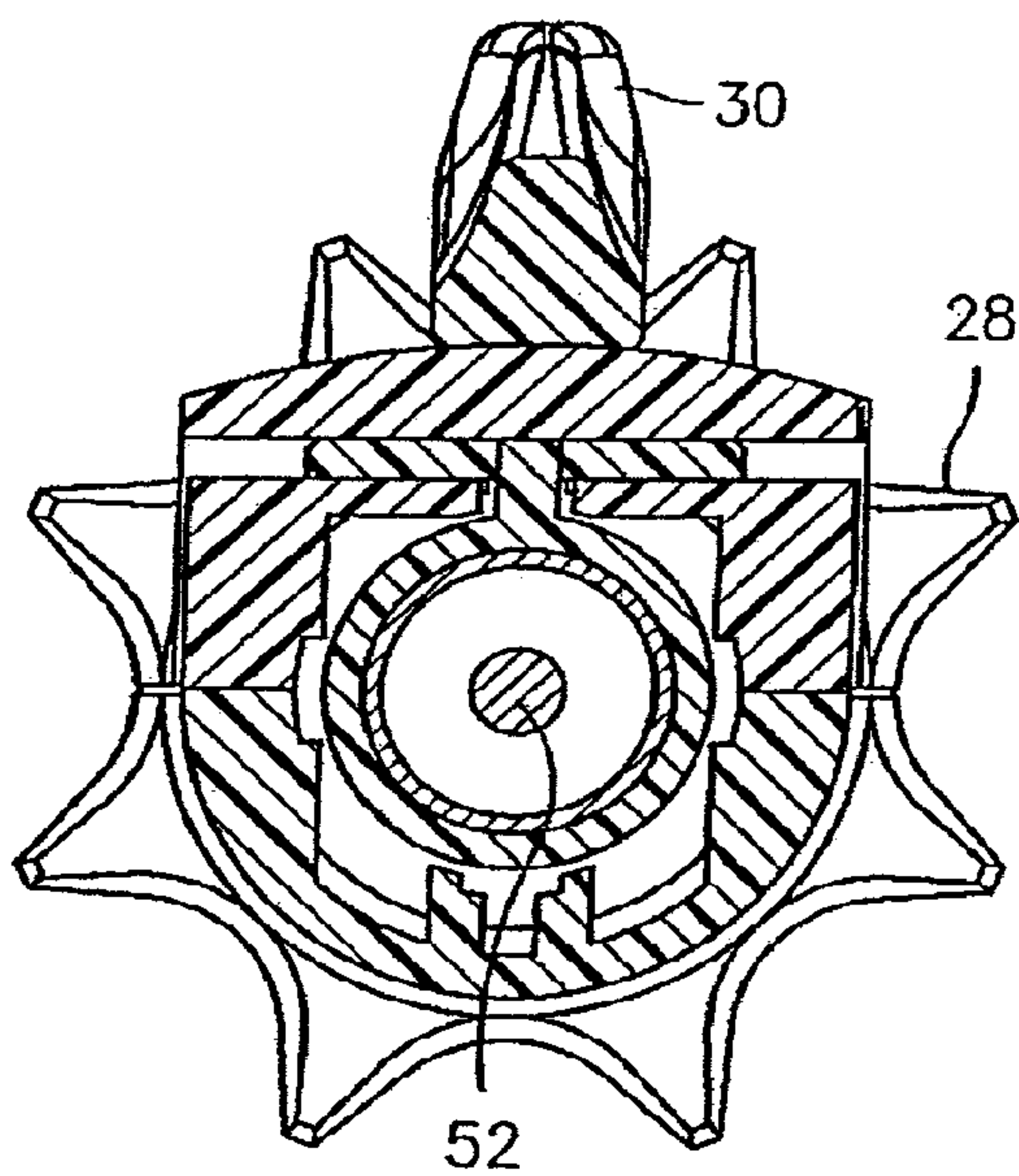


FIG. 15

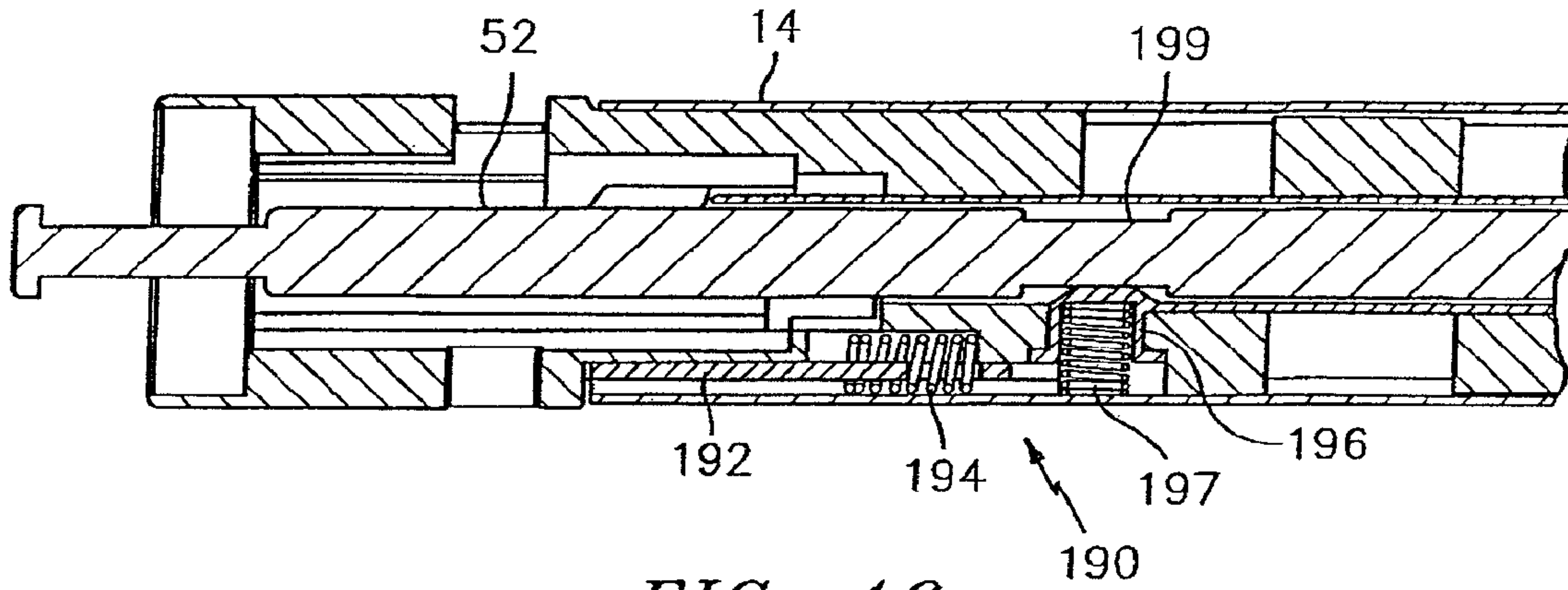


FIG. 16

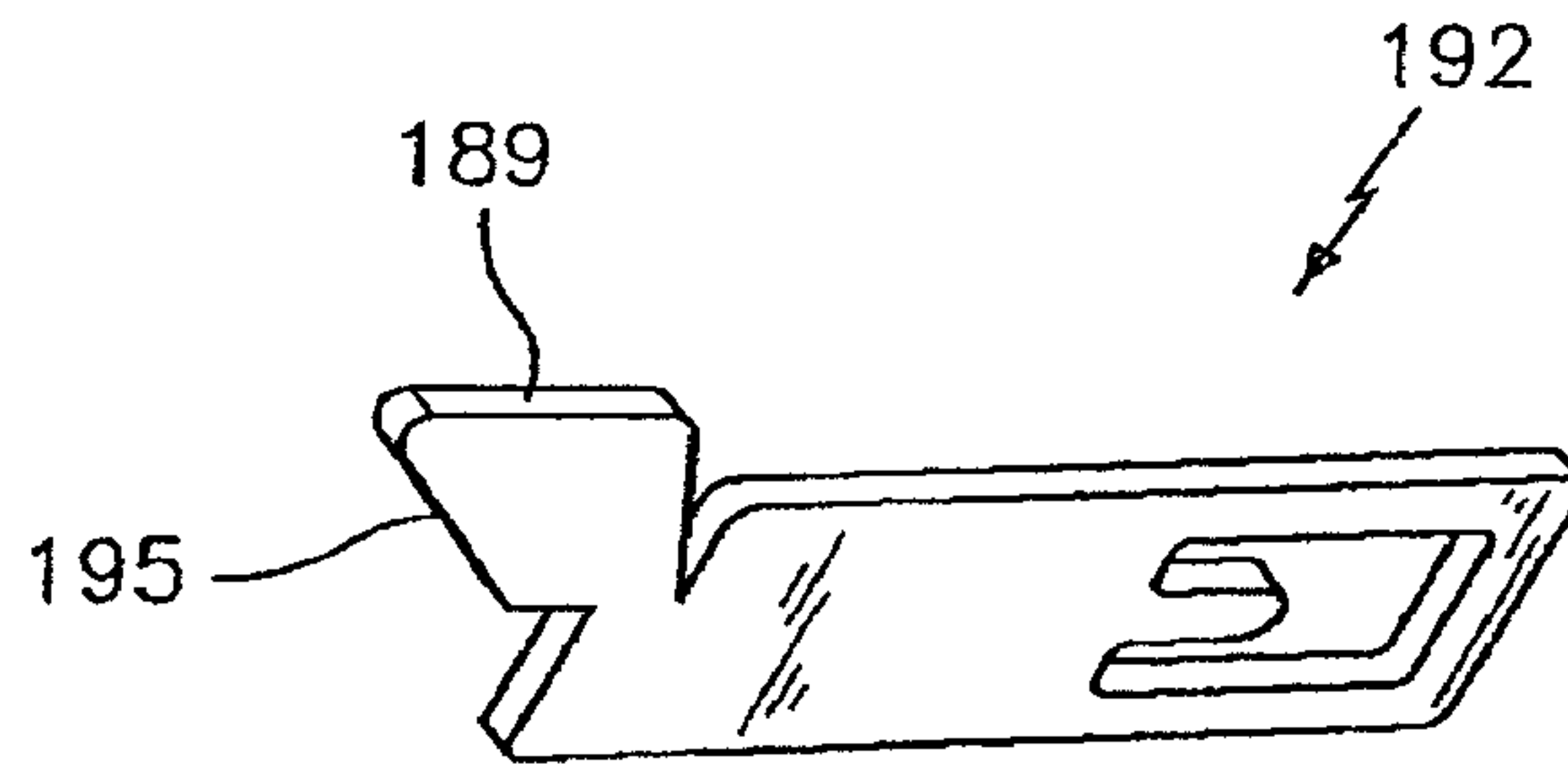


FIG. 17

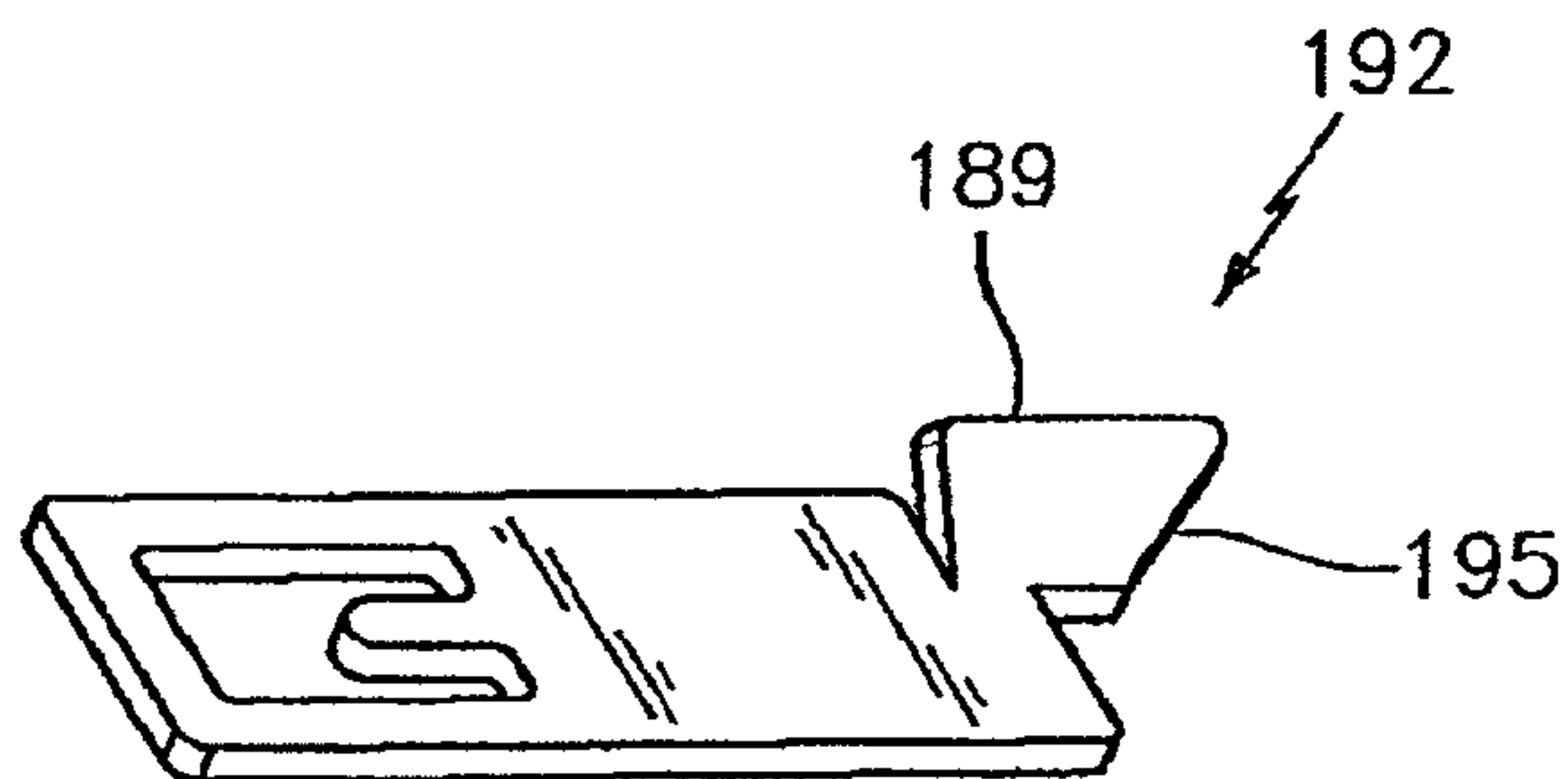


FIG. 18

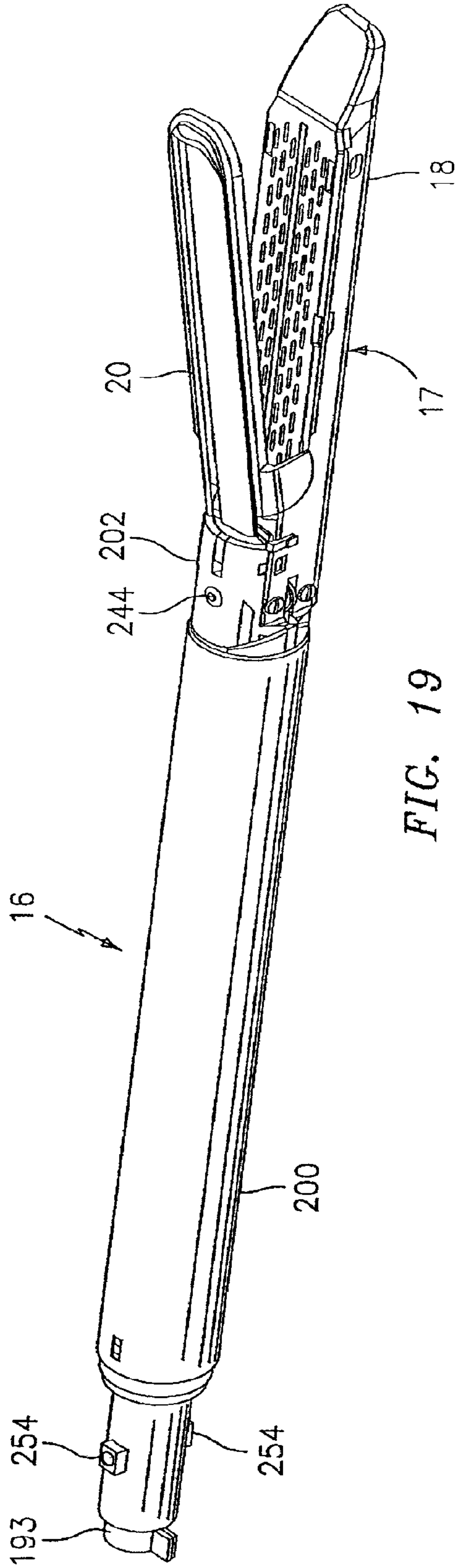


FIG. 19

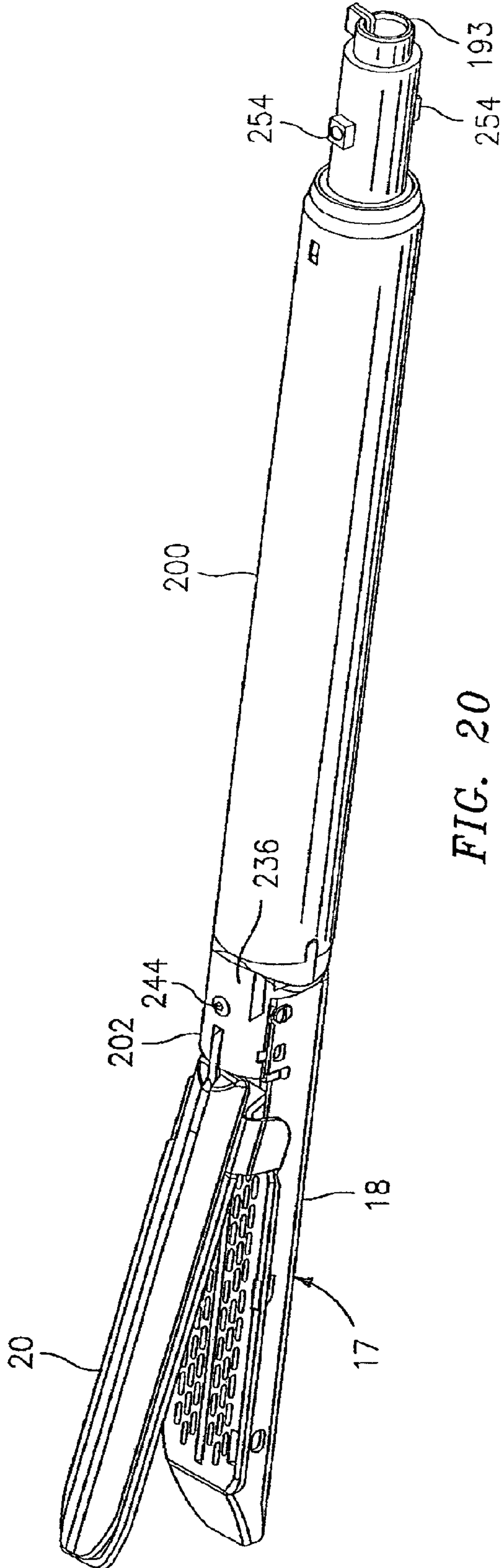


FIG. 20

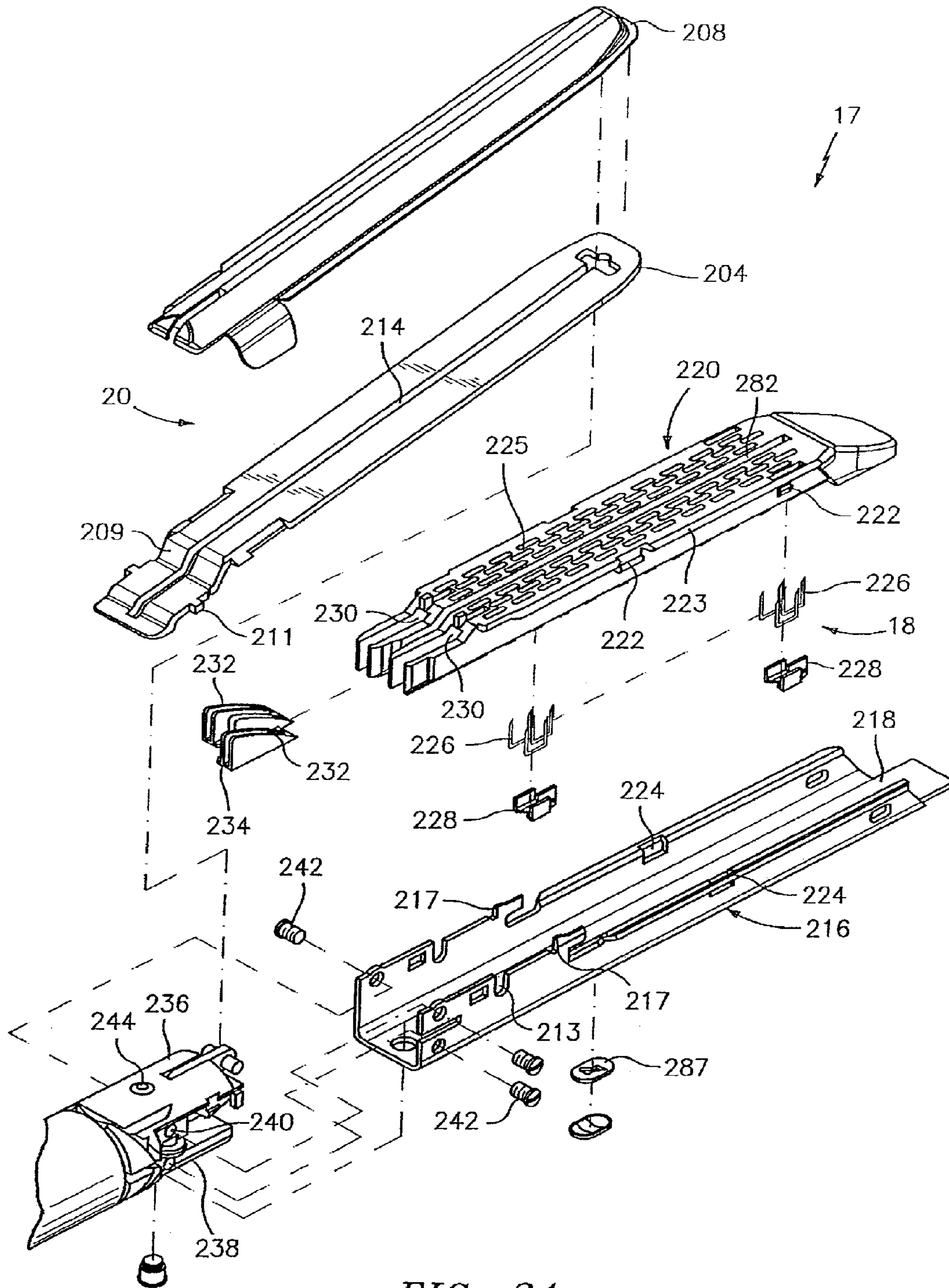


FIG. 21

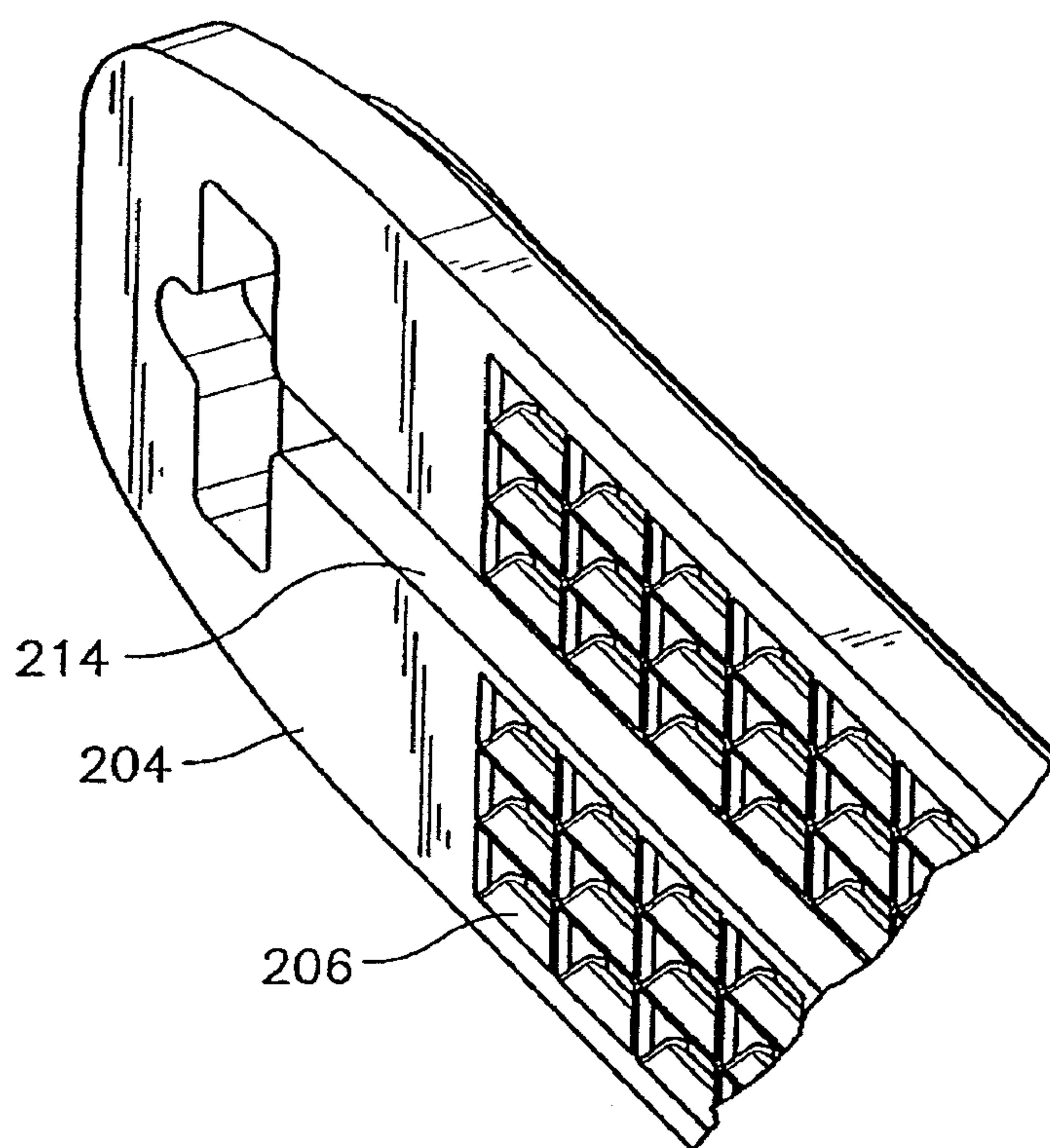


FIG. 22

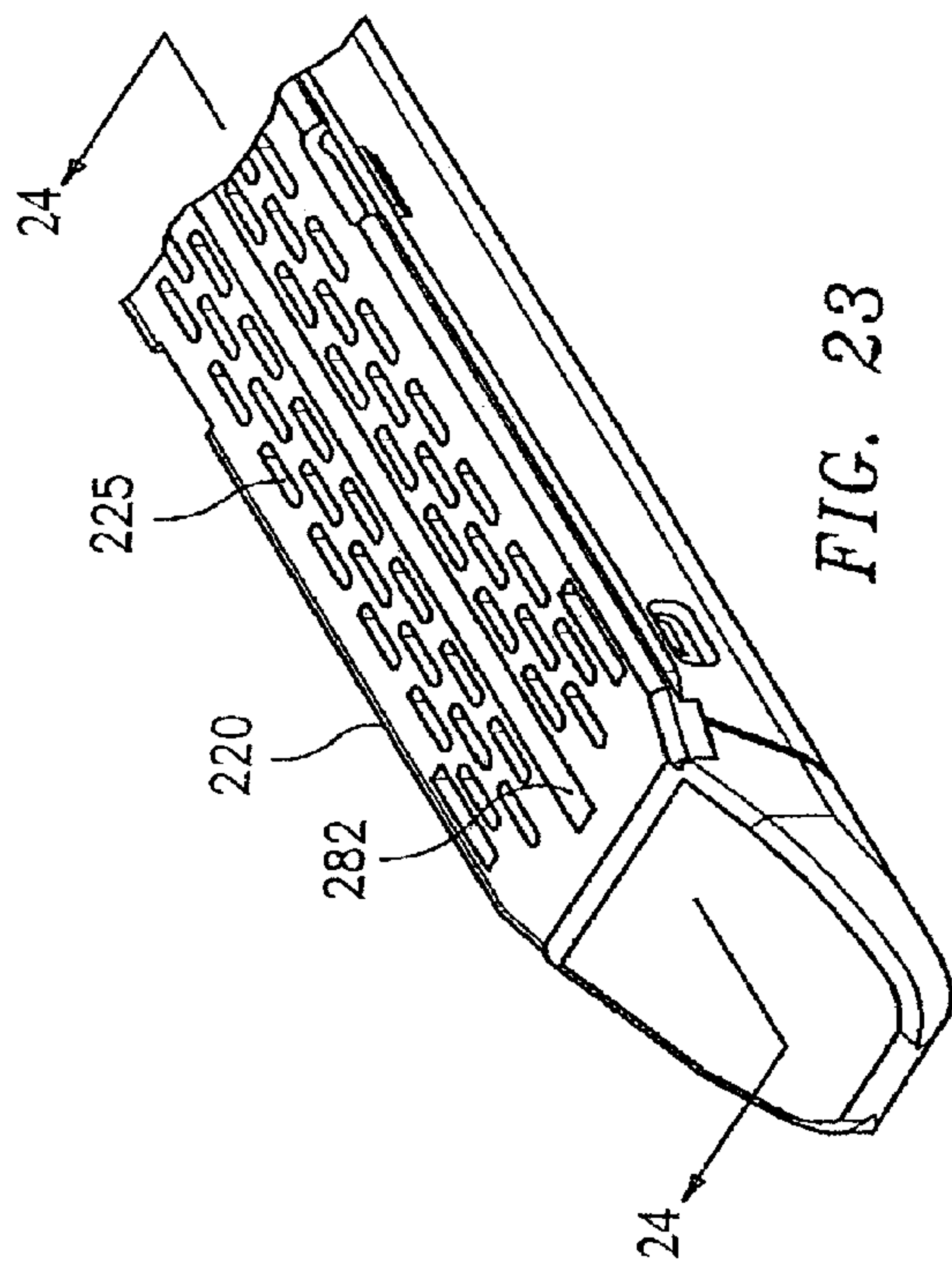


FIG. 23

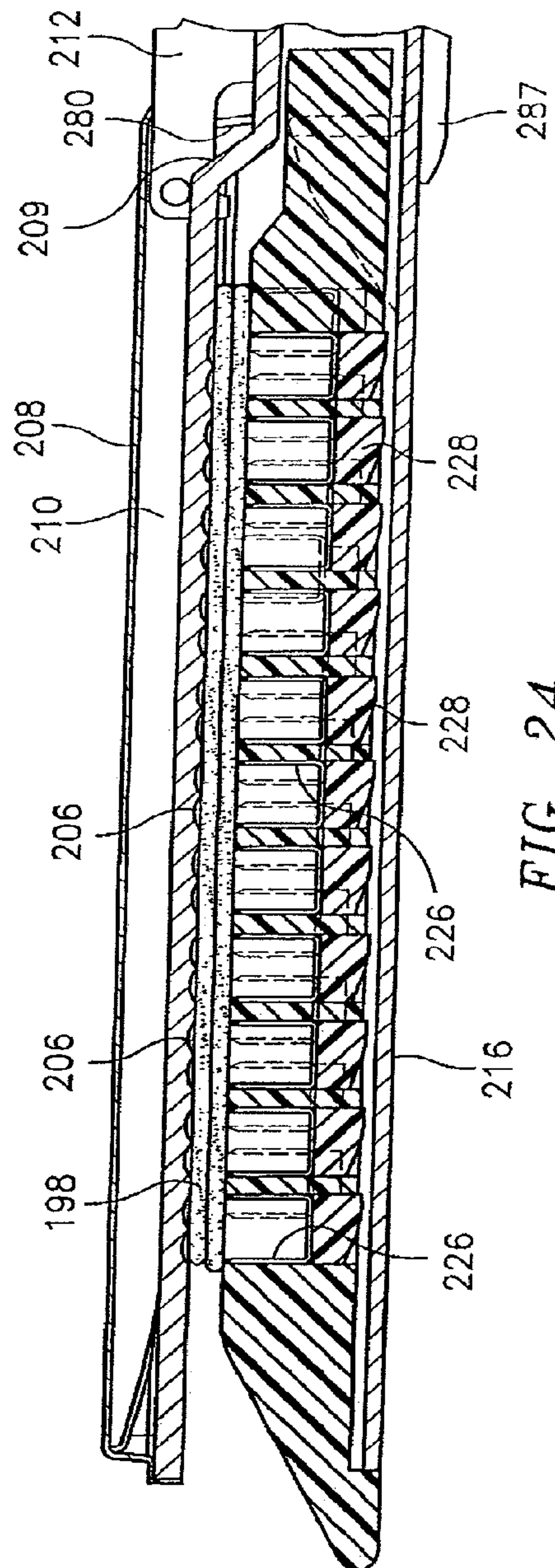


FIG. 24

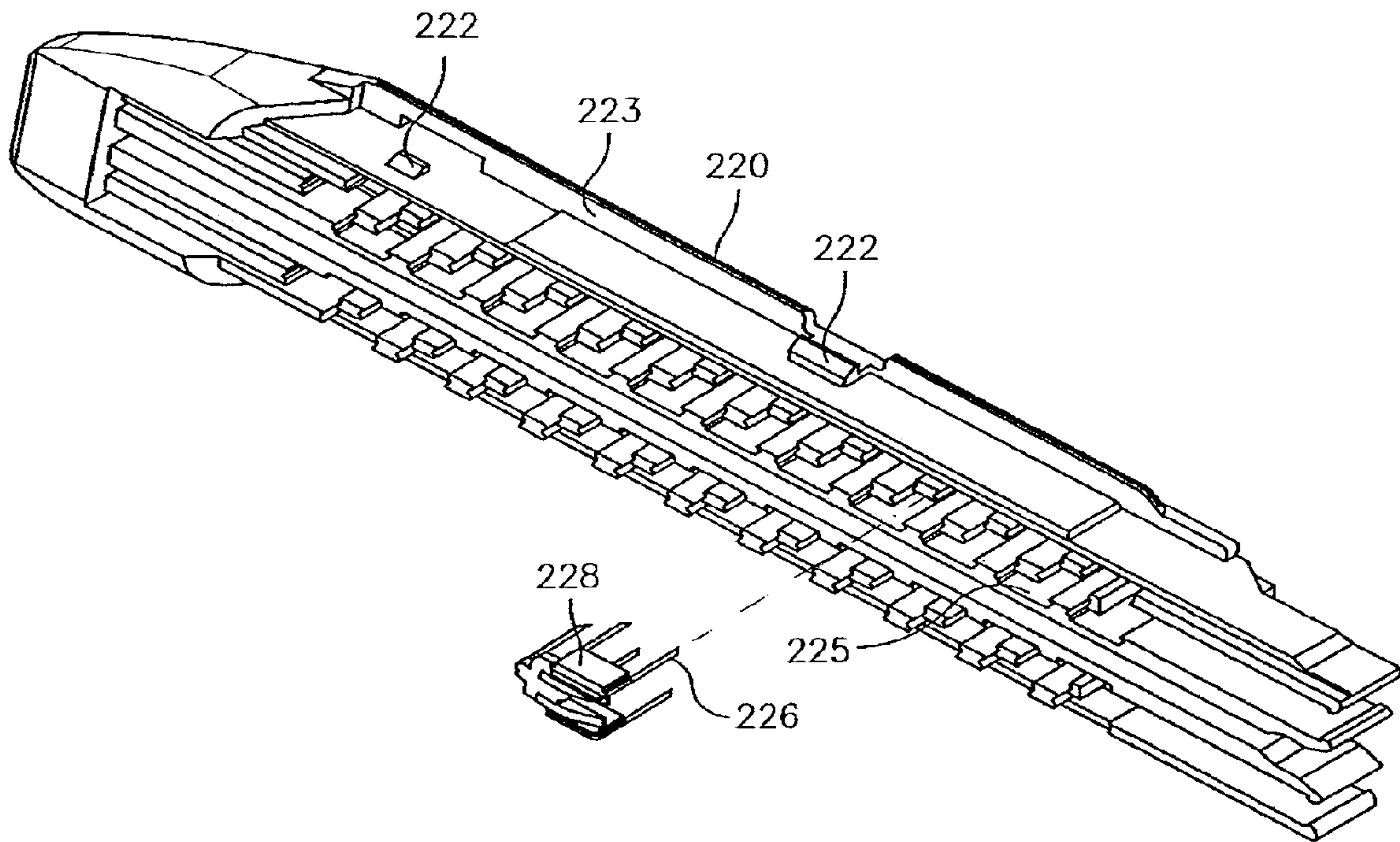


FIG. 25

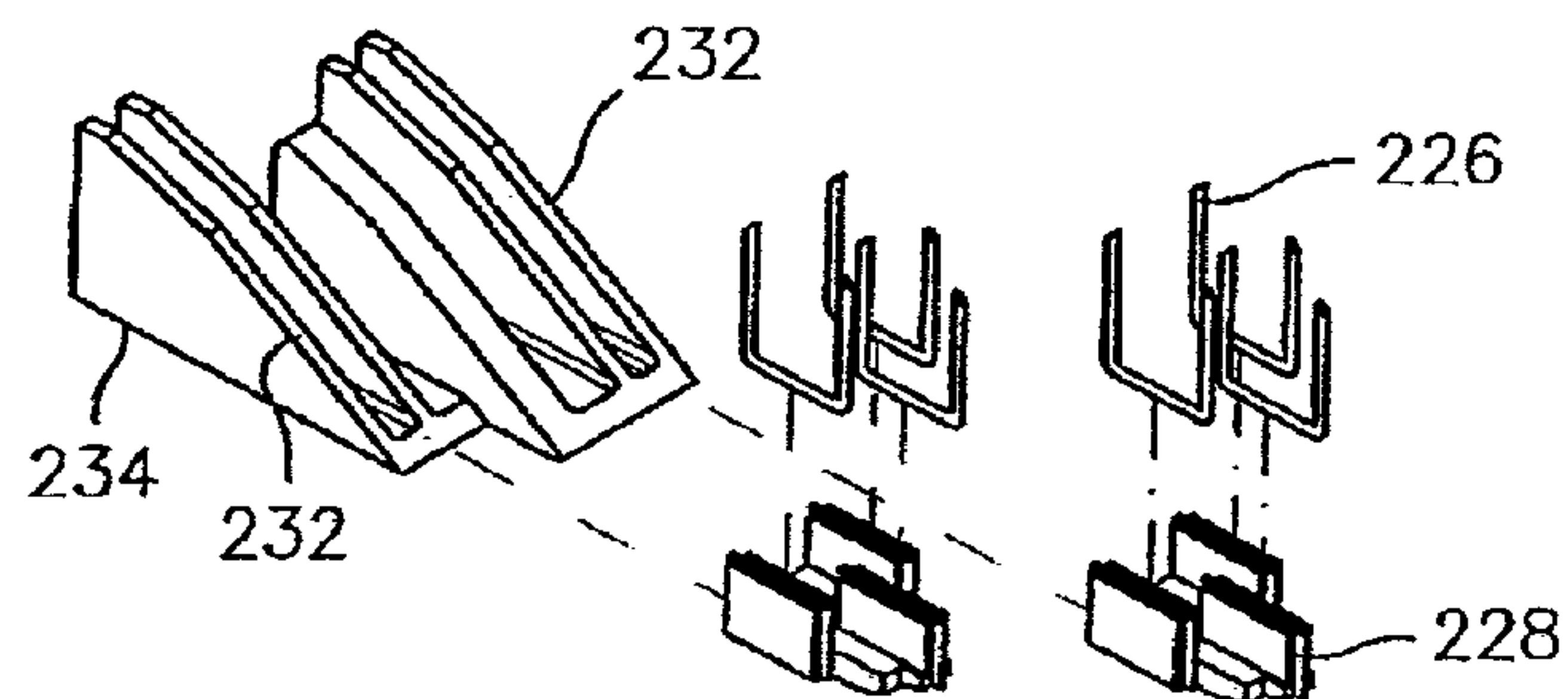


FIG. 26

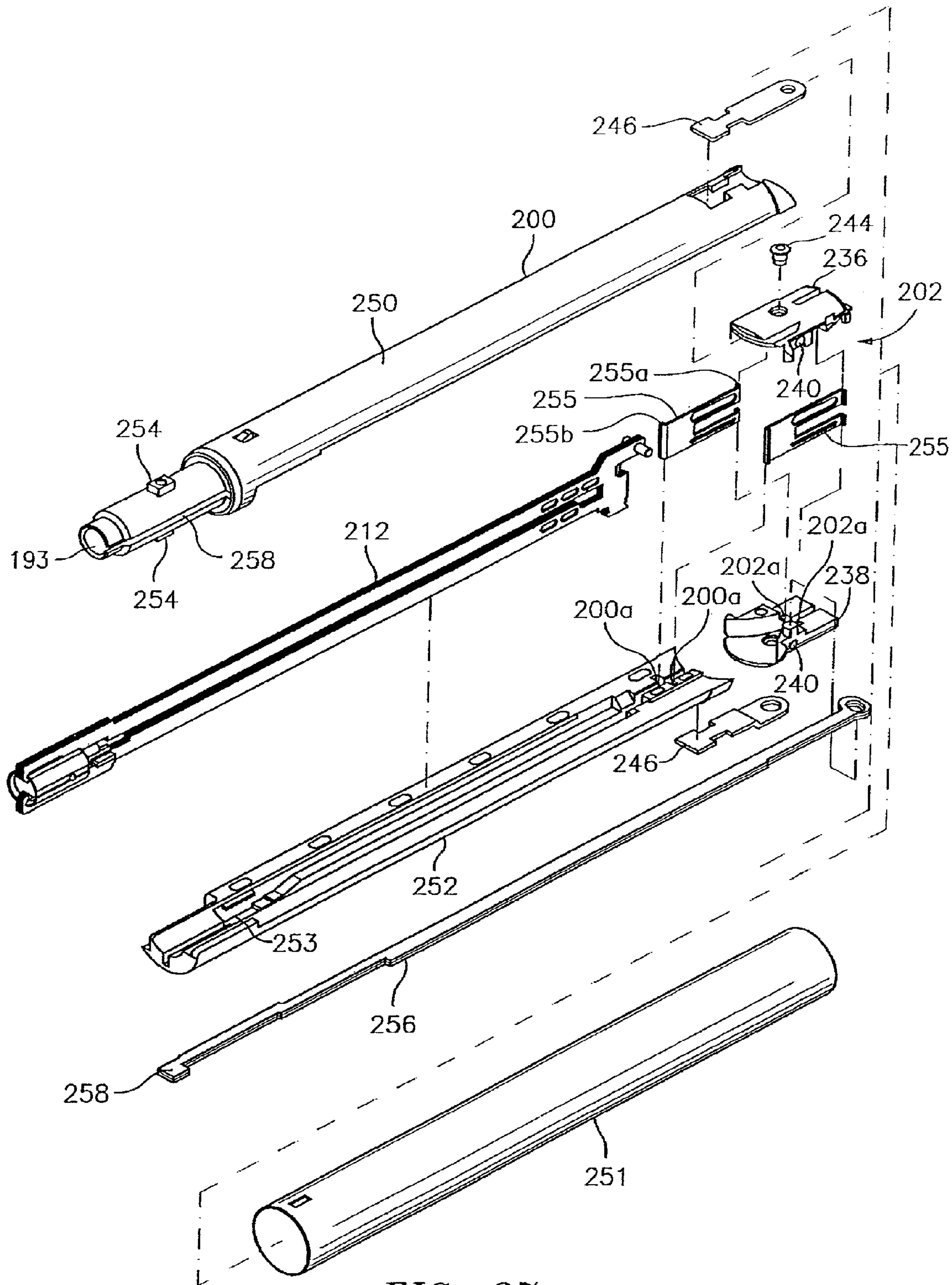


FIG. 27

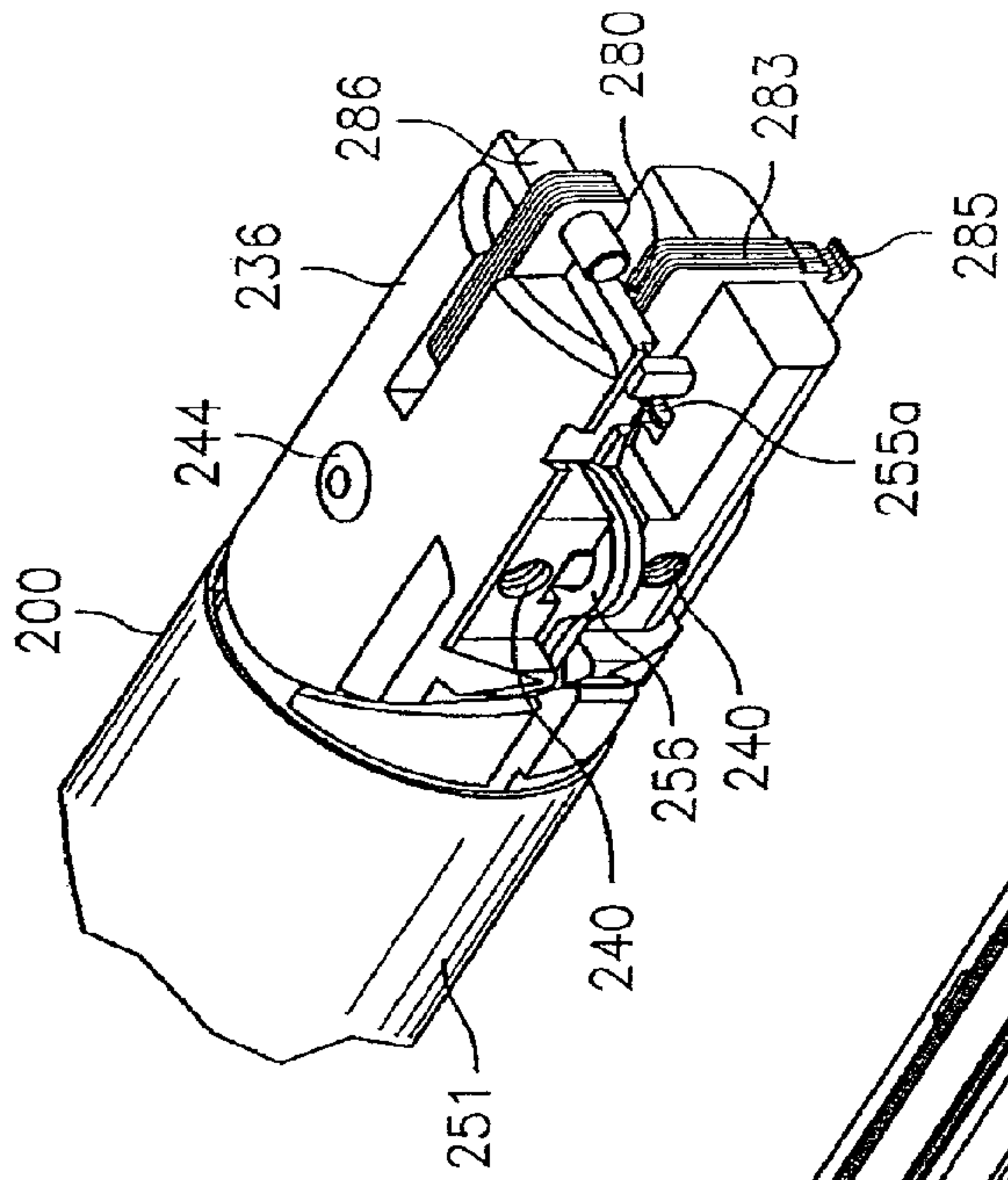


FIG. 28

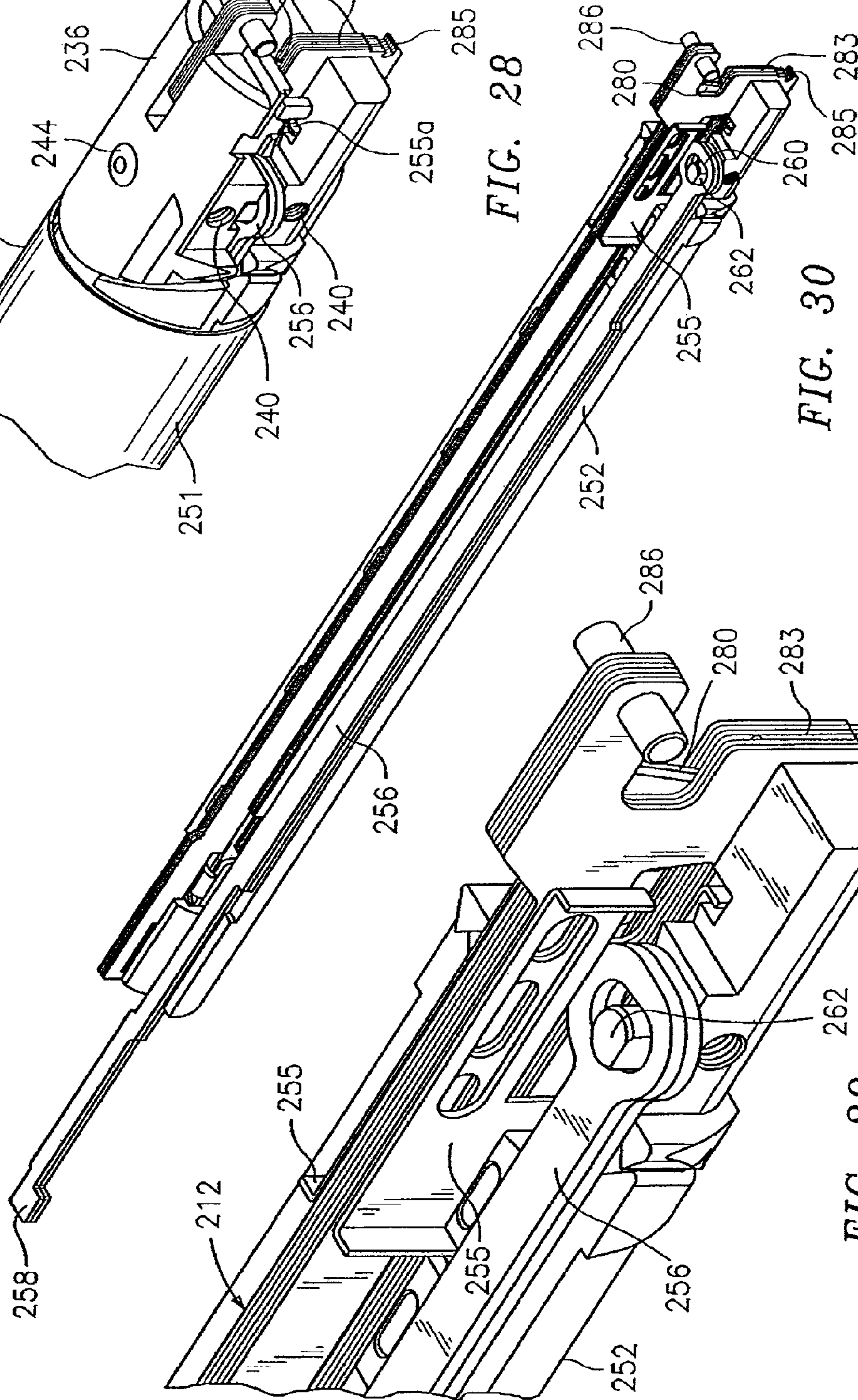


FIG. 29

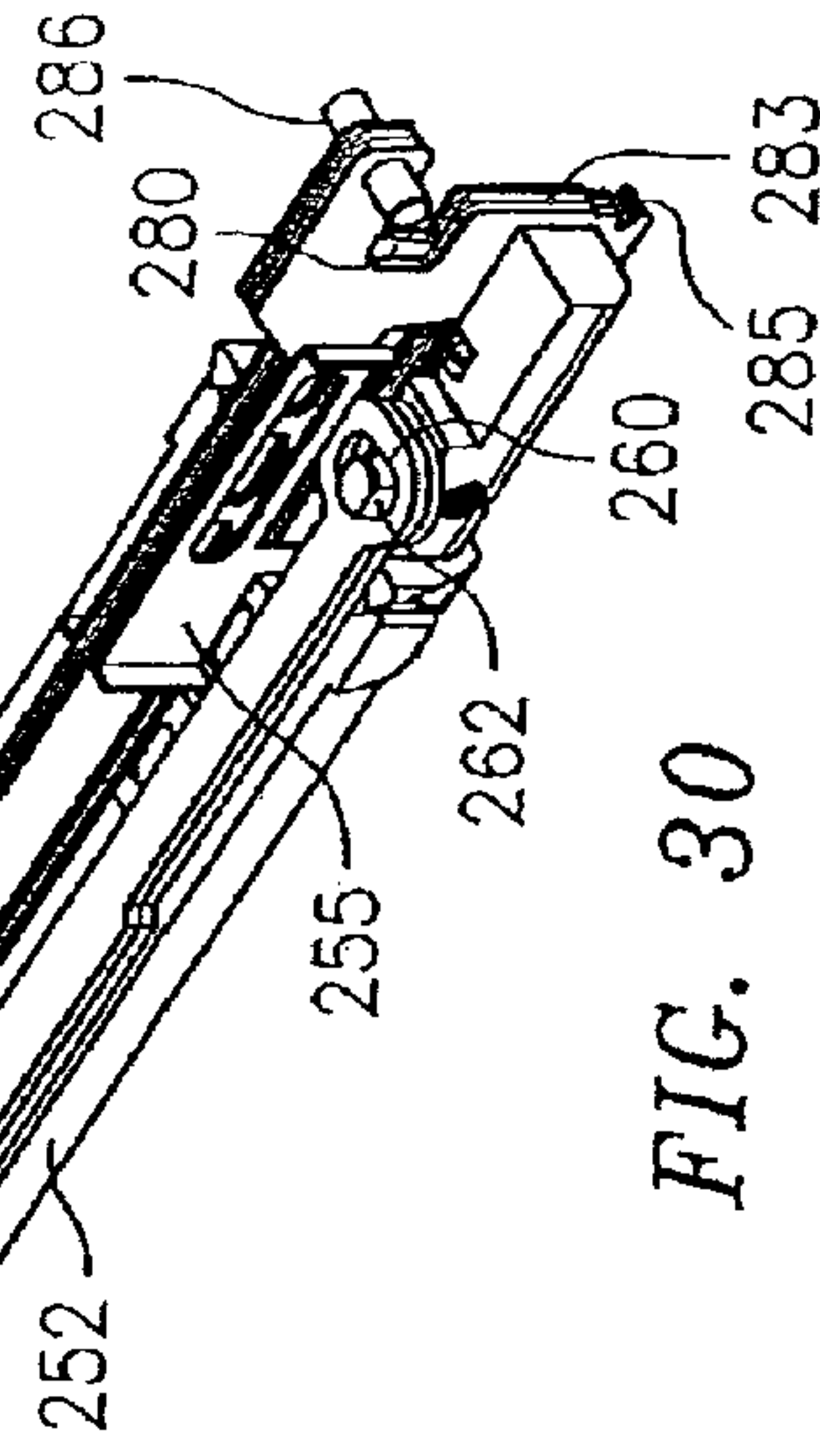


FIG. 30

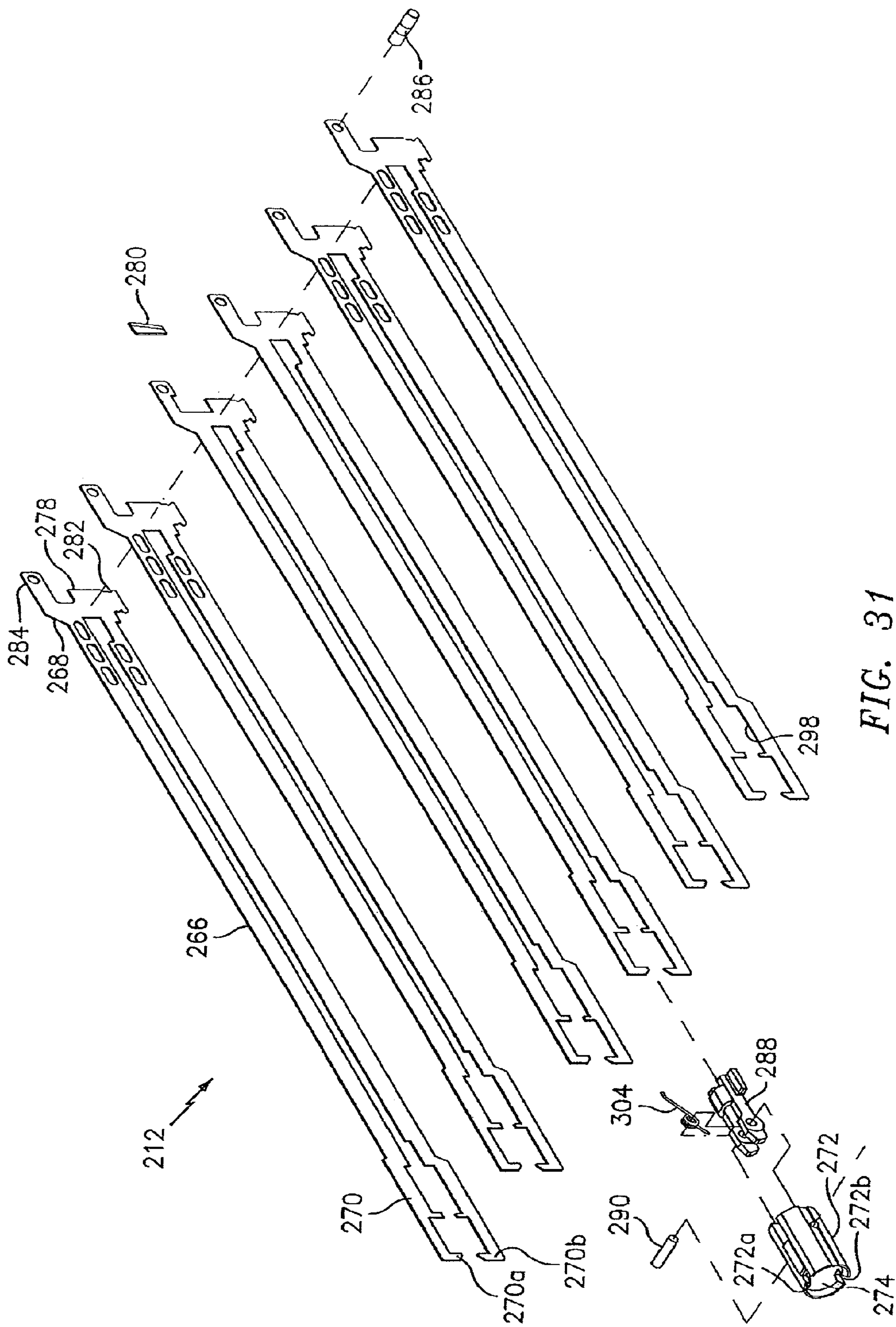
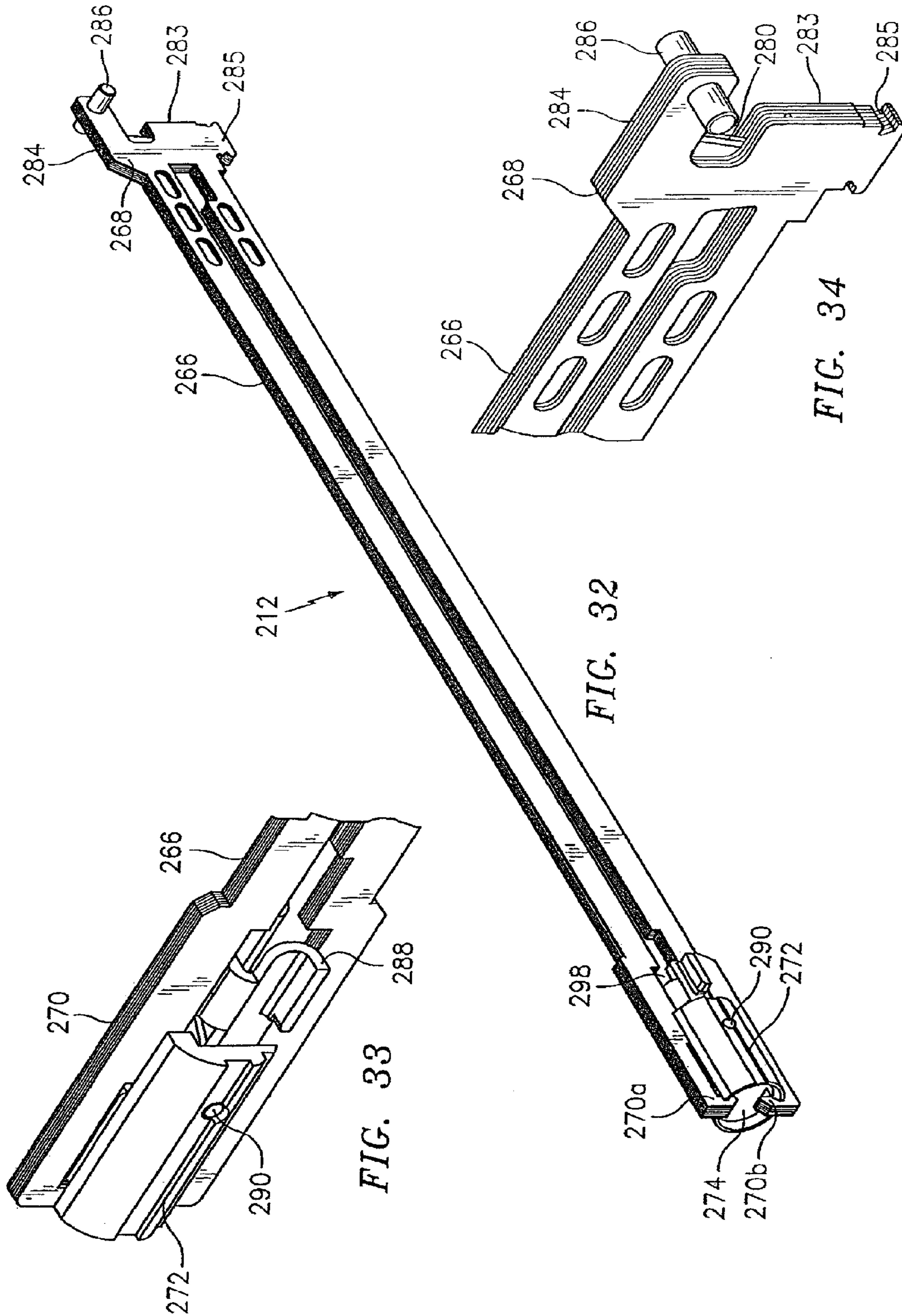


FIG. 31



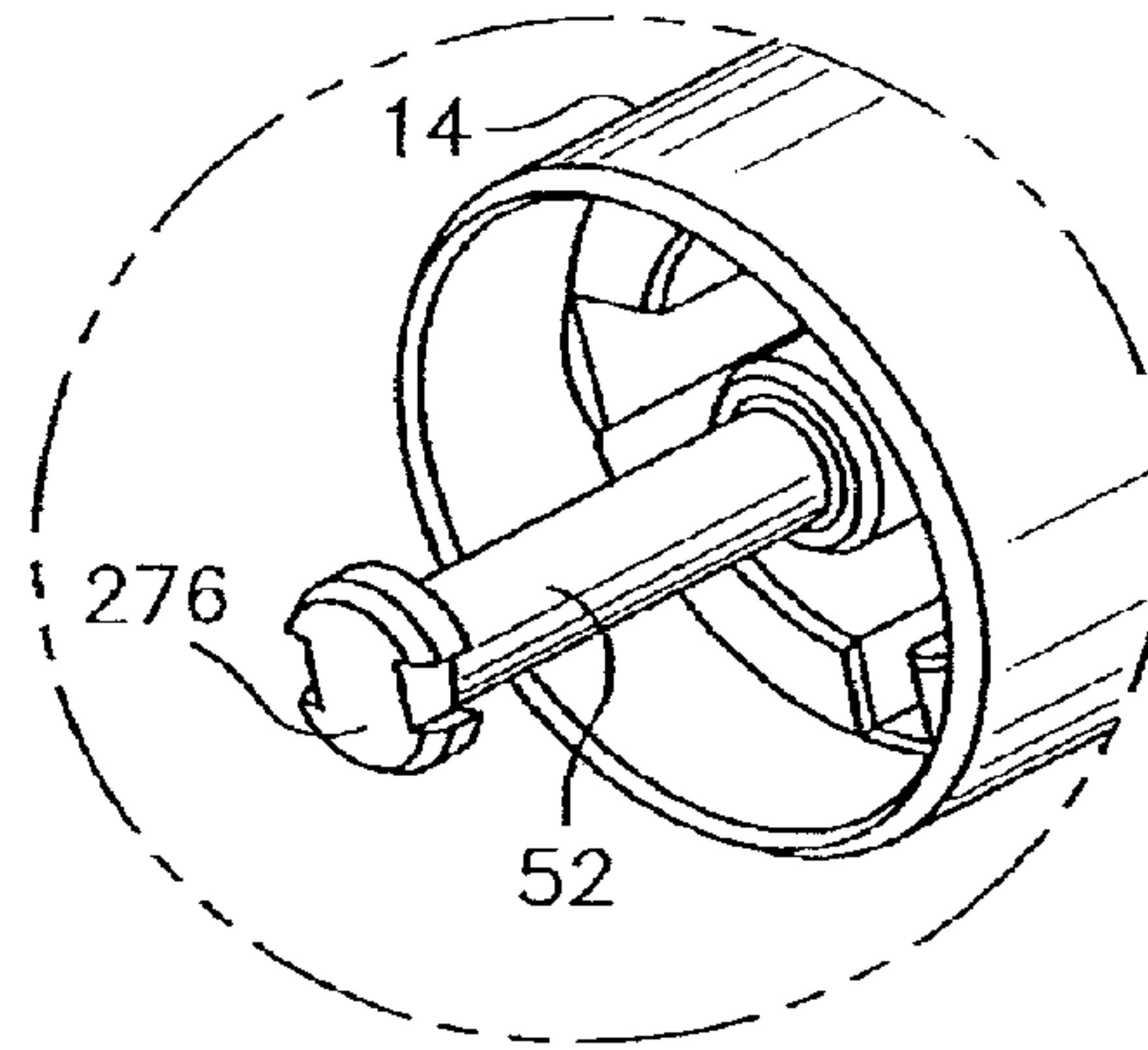


FIG. 35

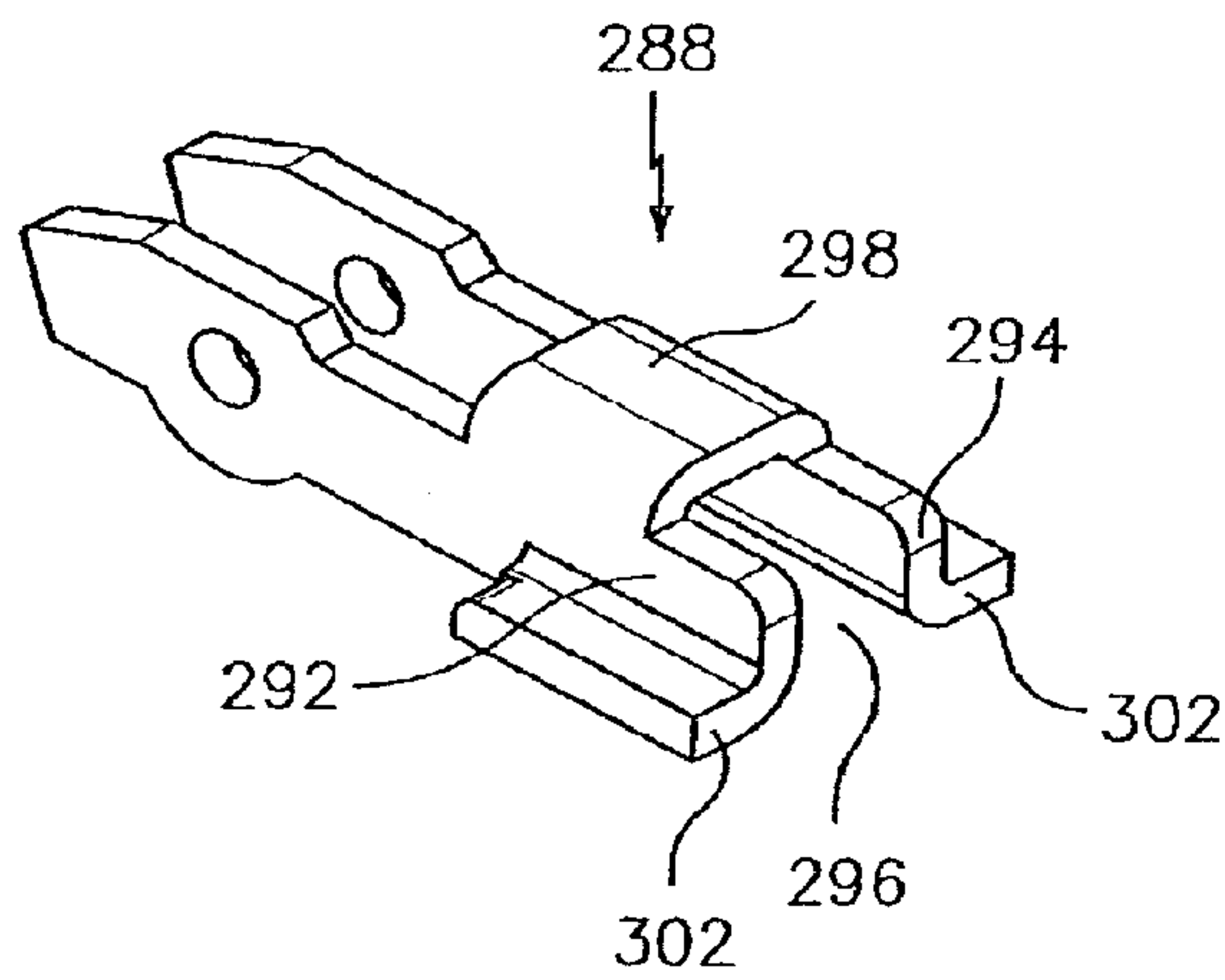


FIG. 36

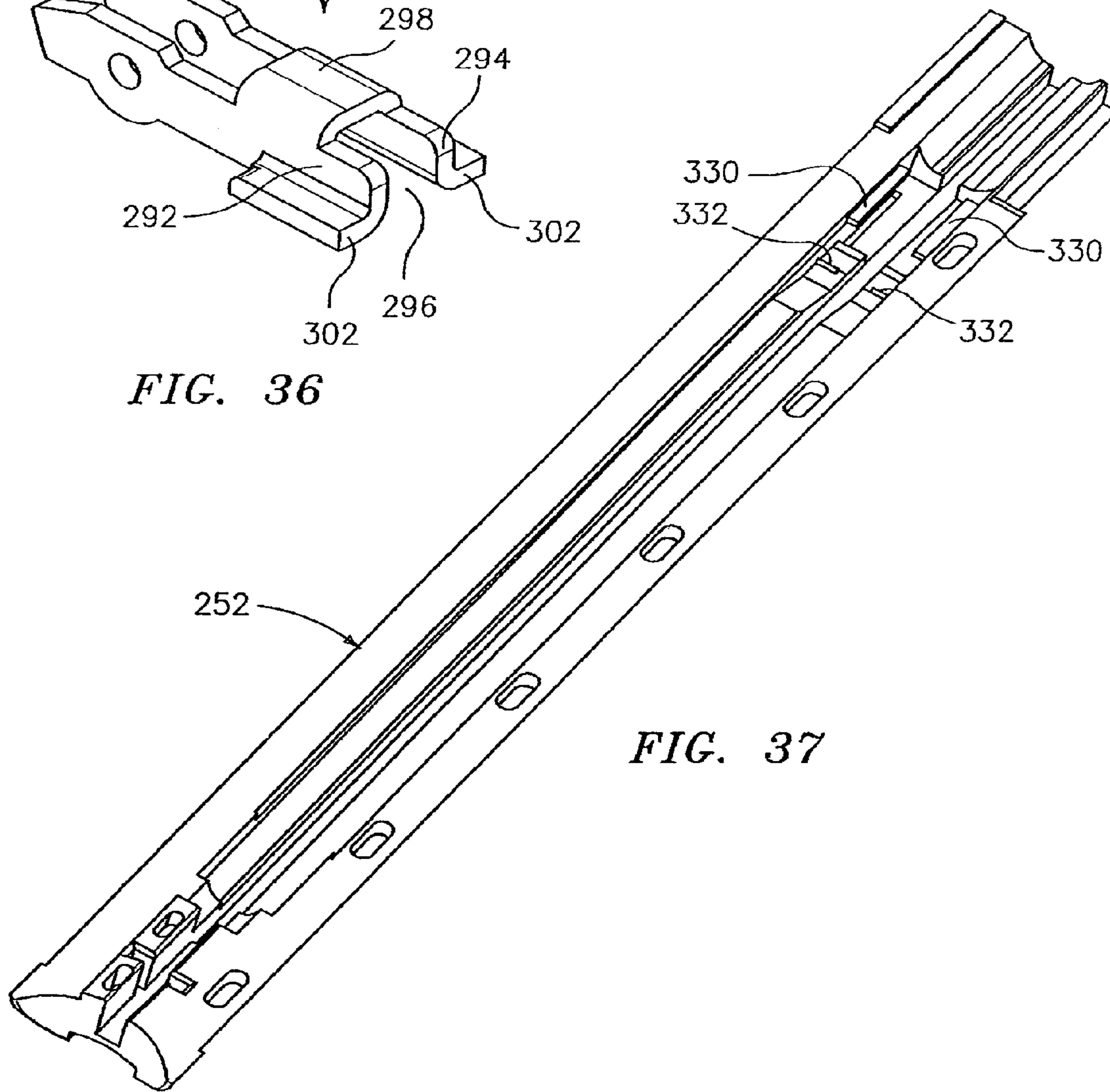


FIG. 37

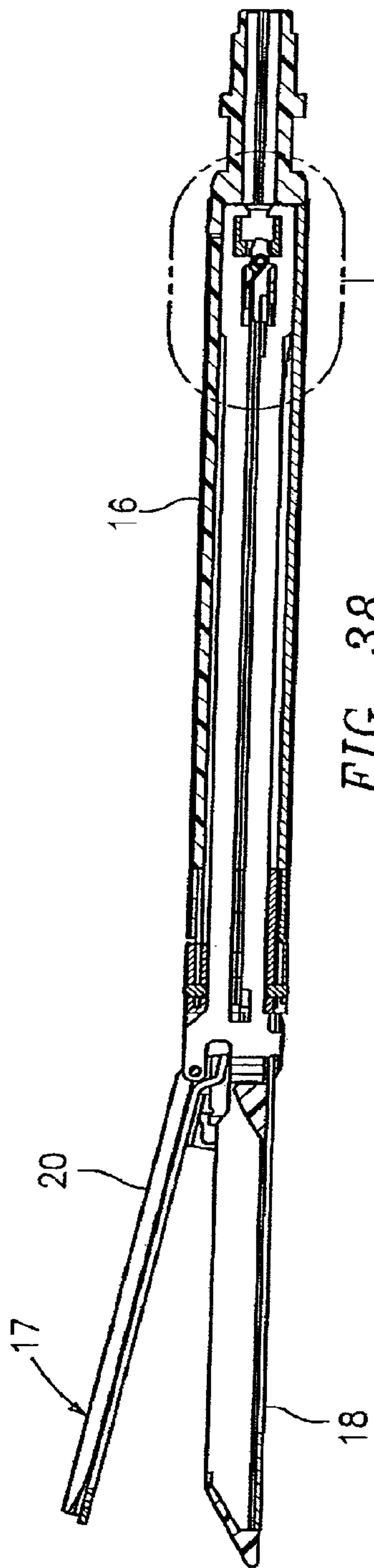


FIG. 38

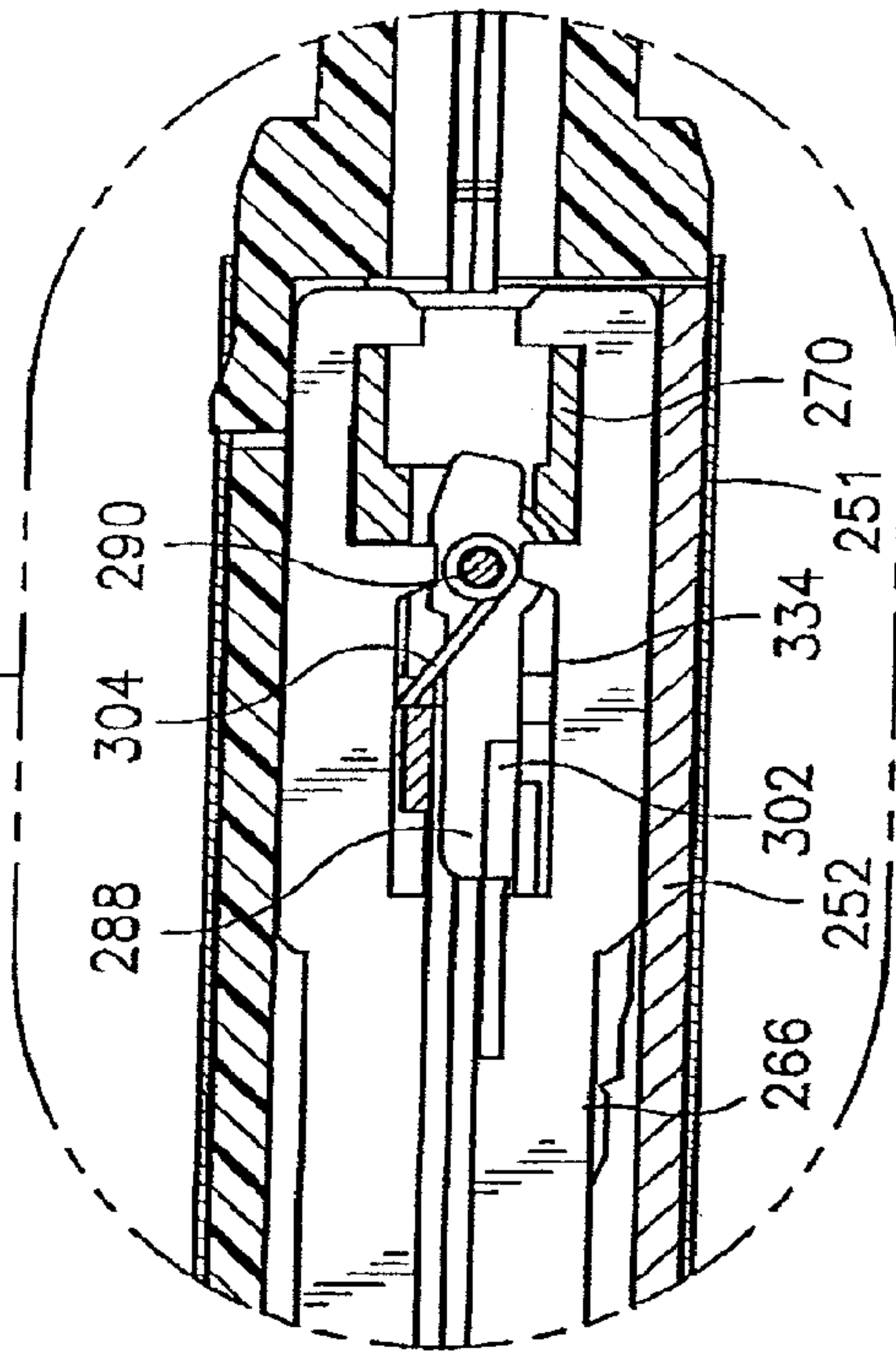


FIG. 39

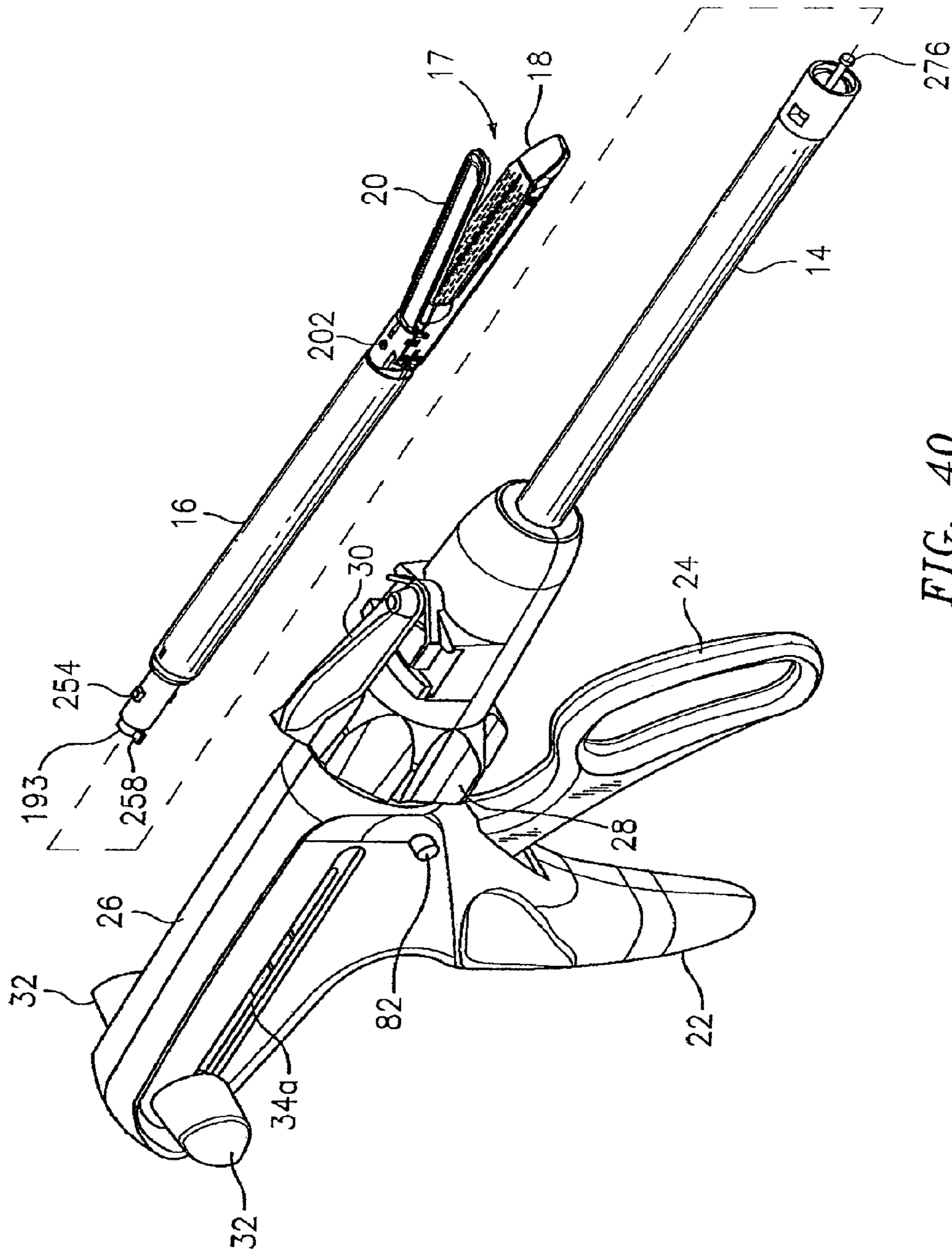
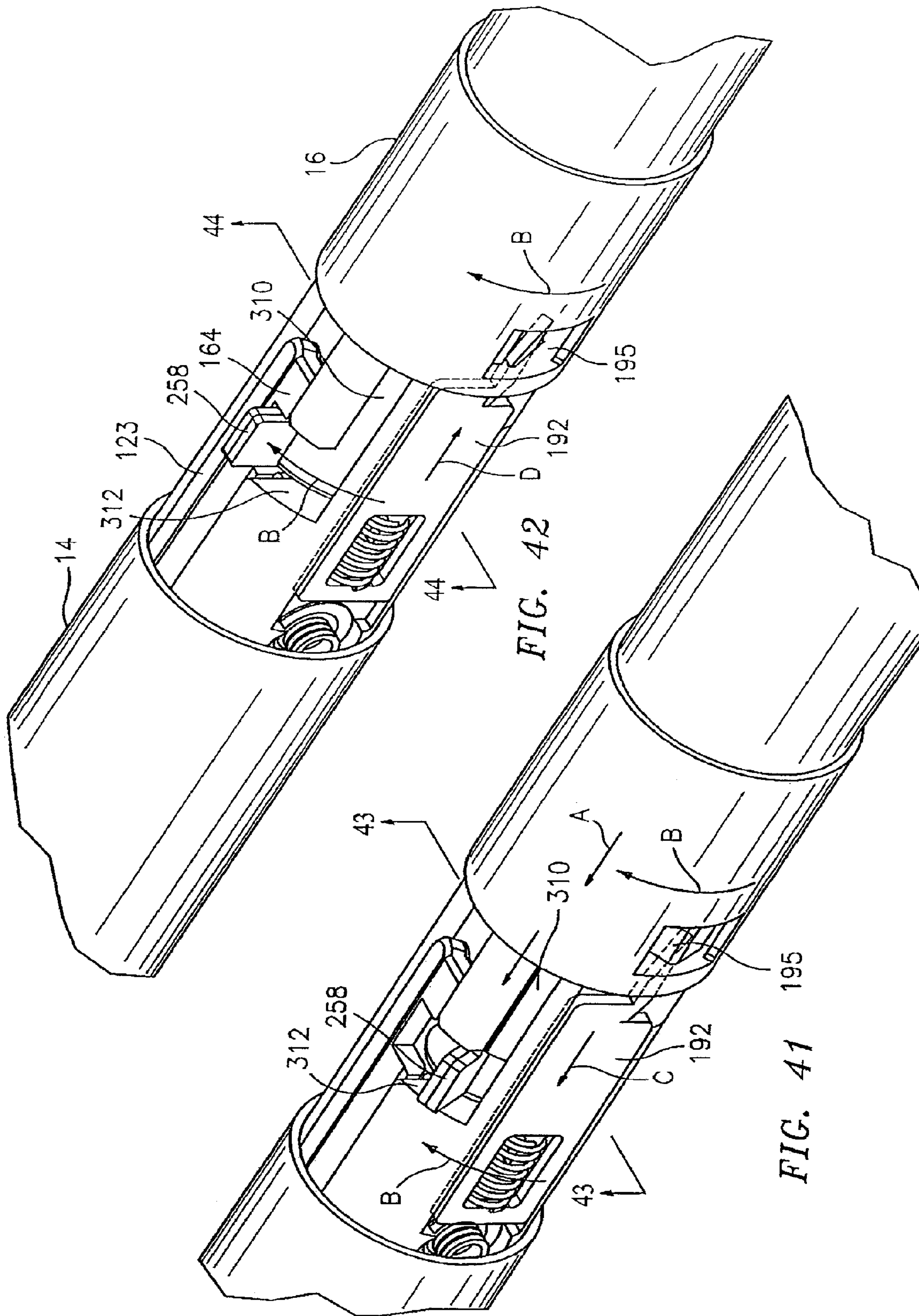


FIG. 40



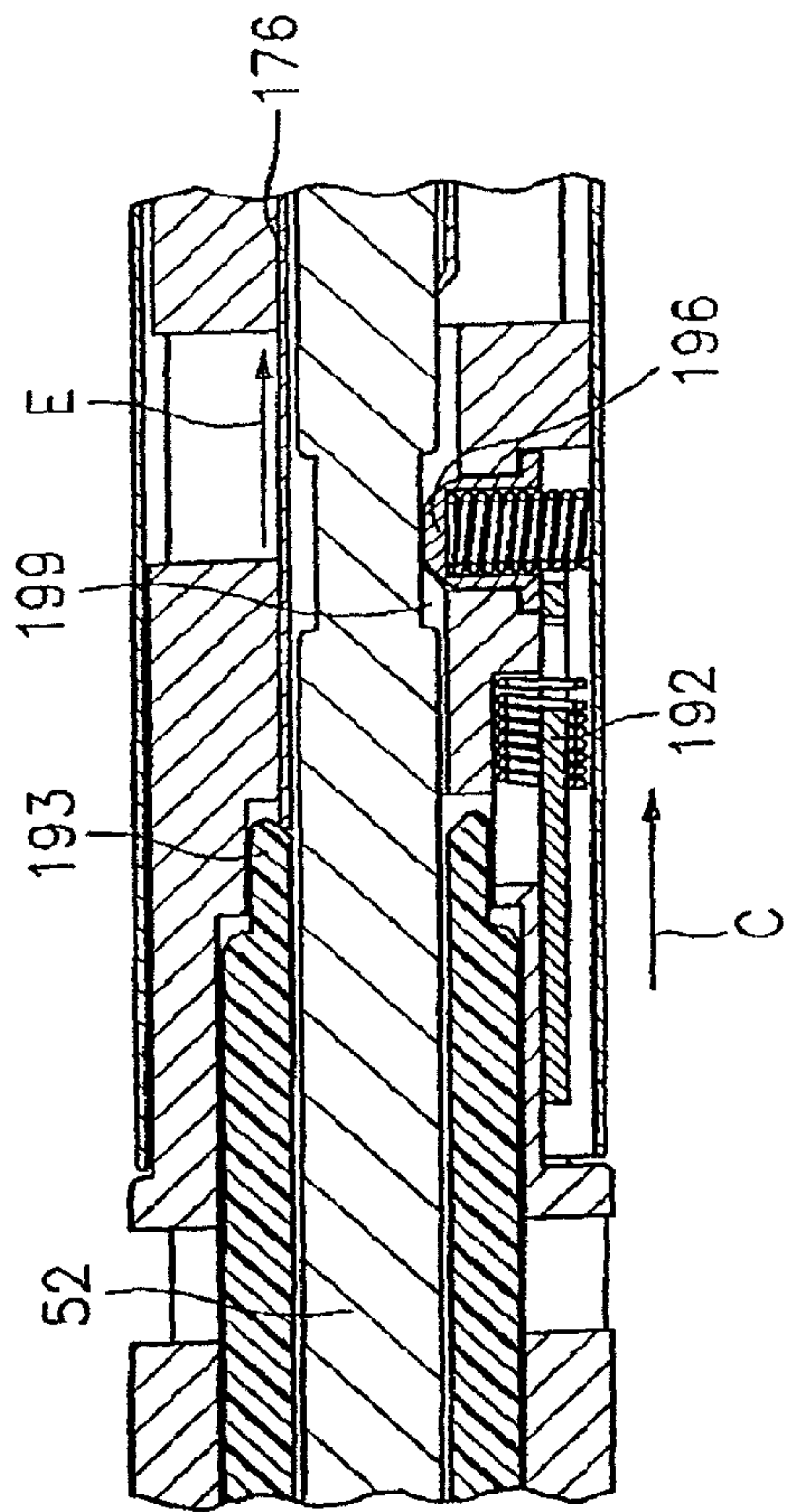


FIG. 43

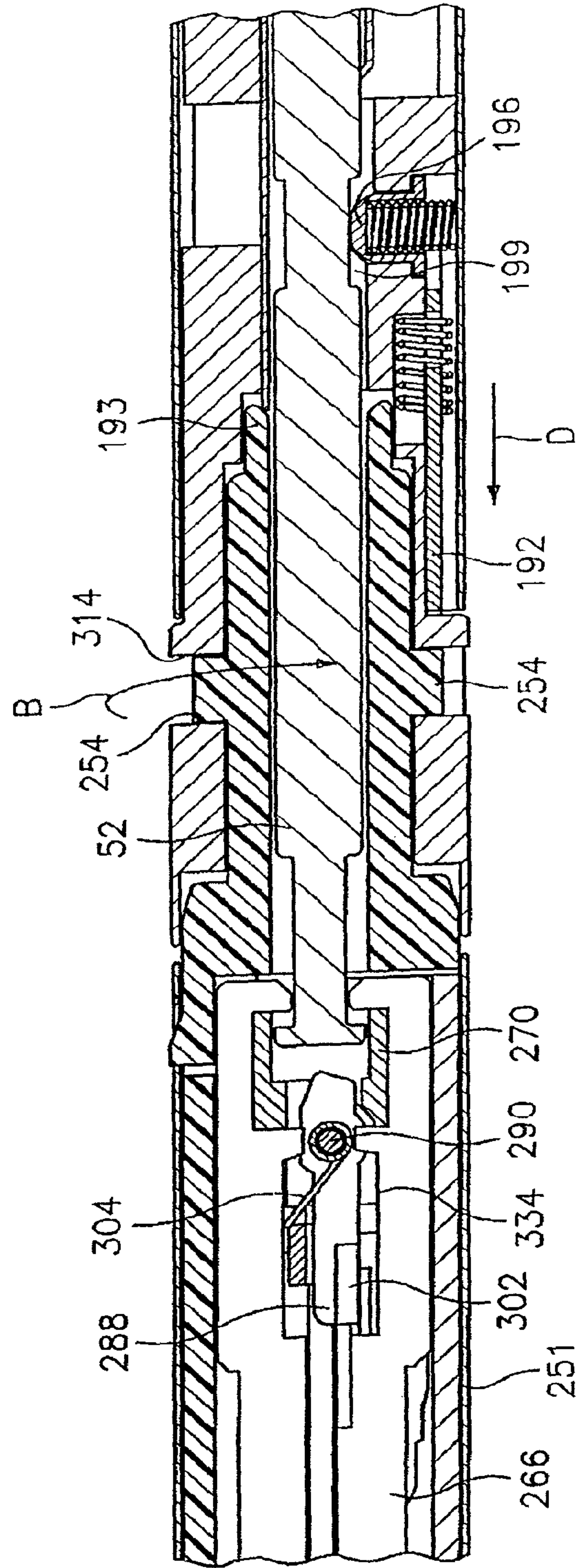


FIG. 44

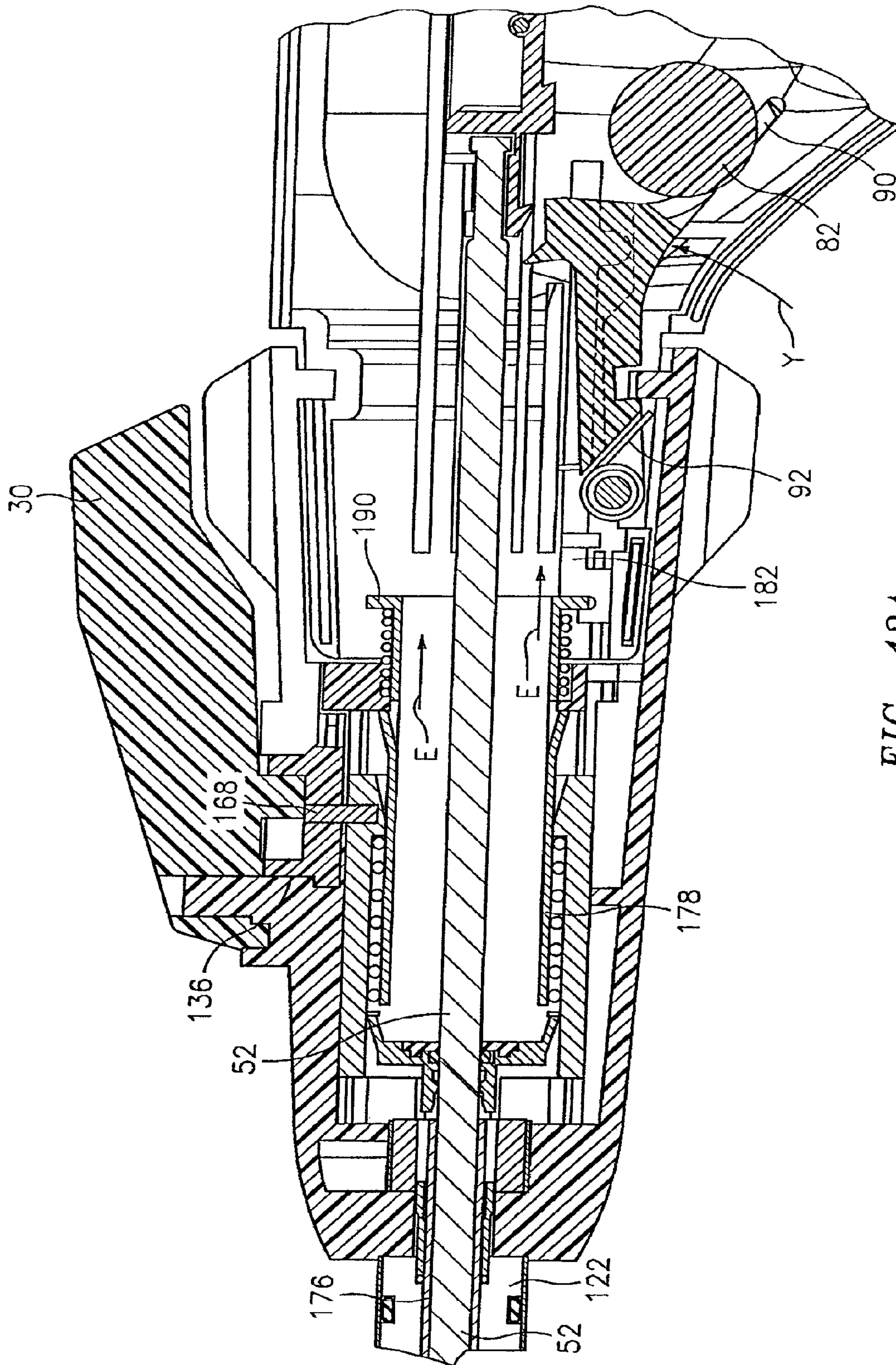


FIG. 43A

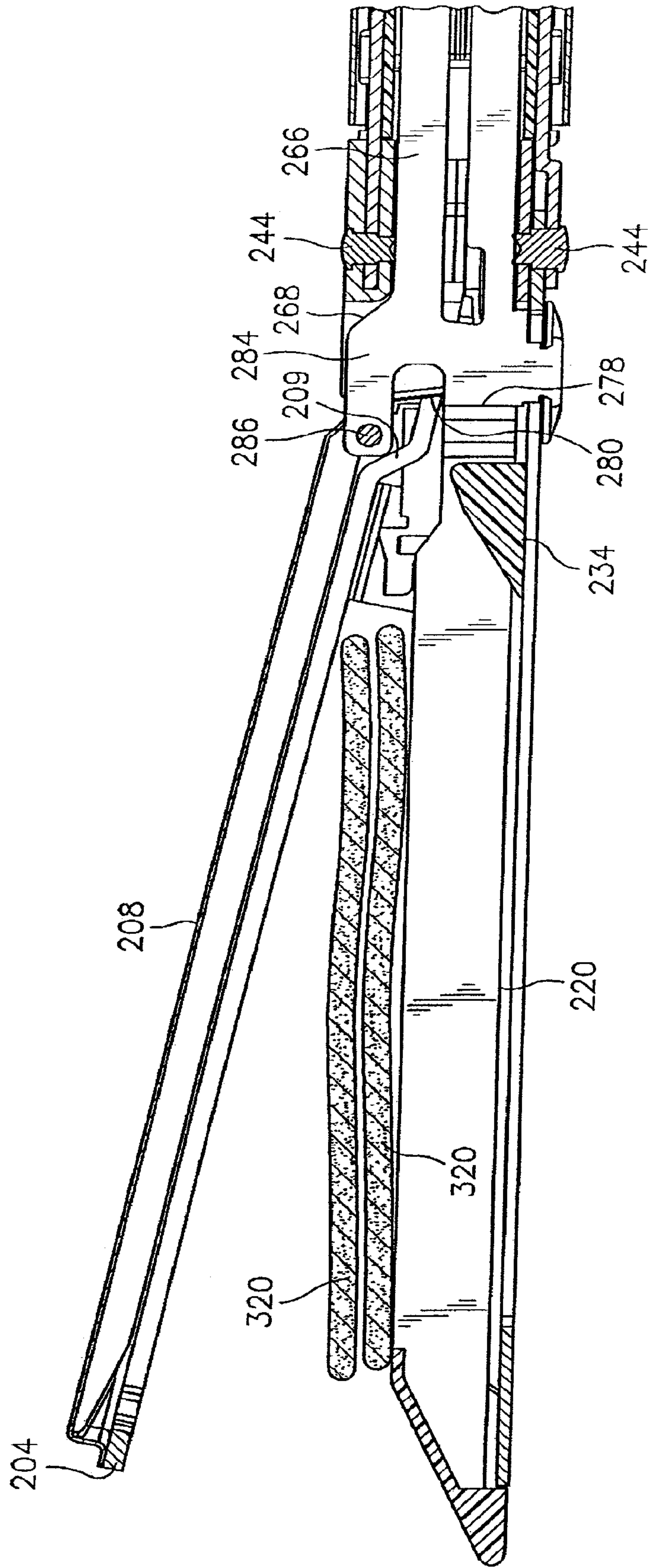


FIG. 45

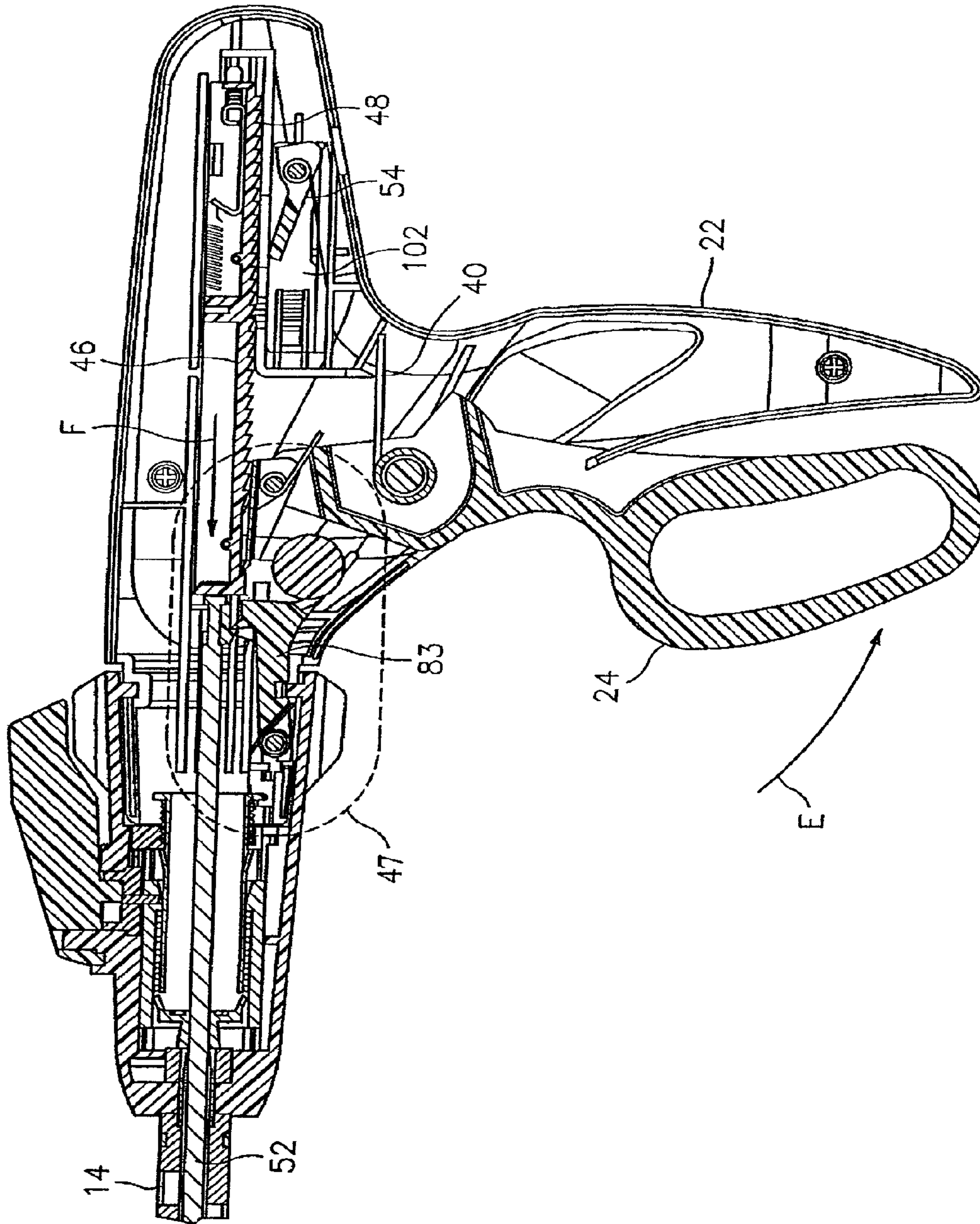


FIG. 46

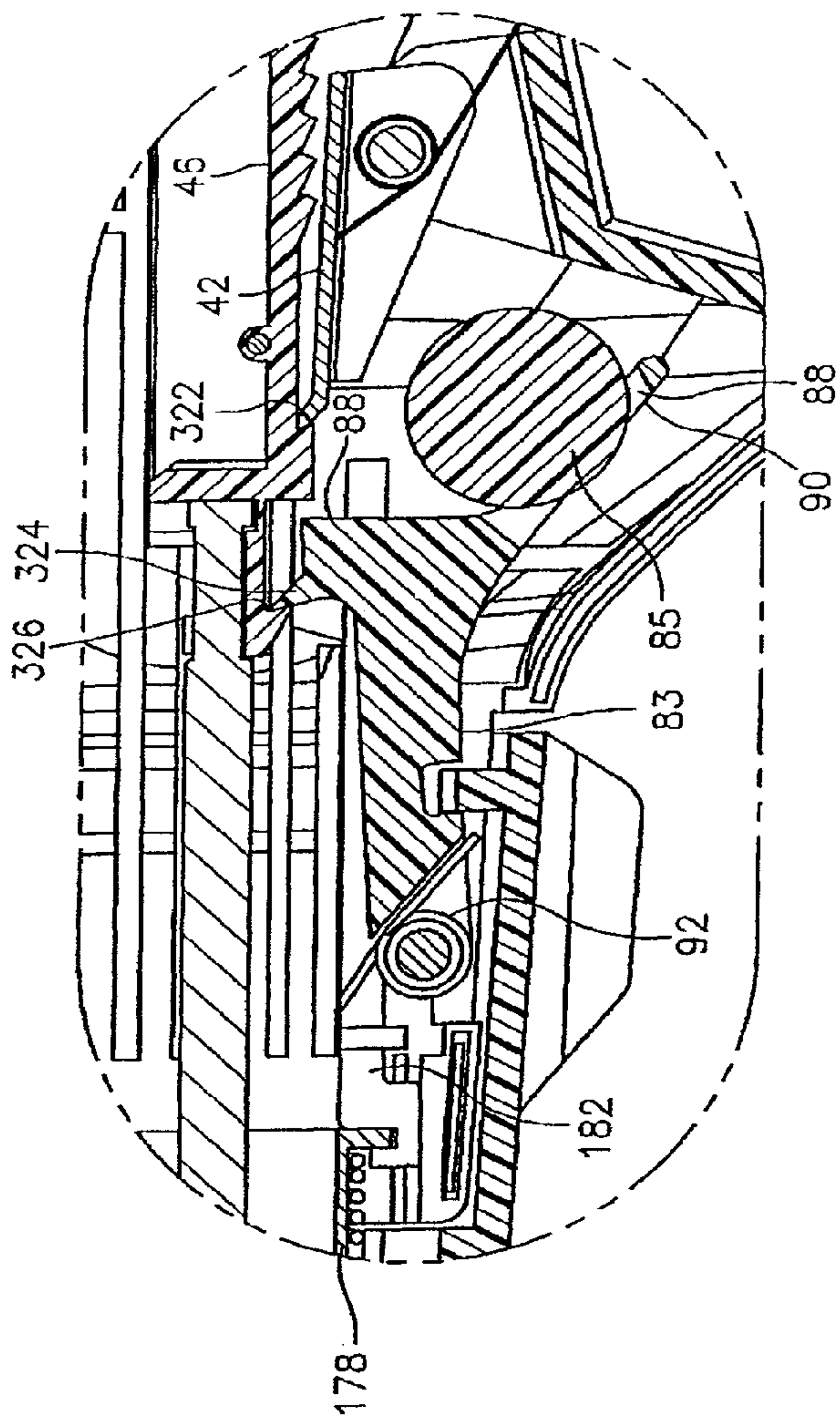


FIG. 47

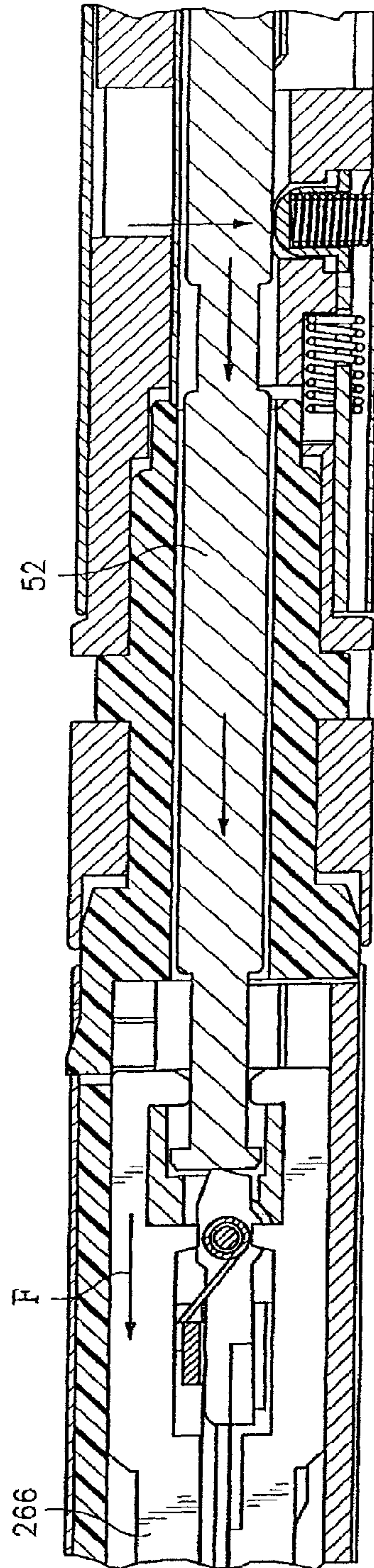


FIG. 48

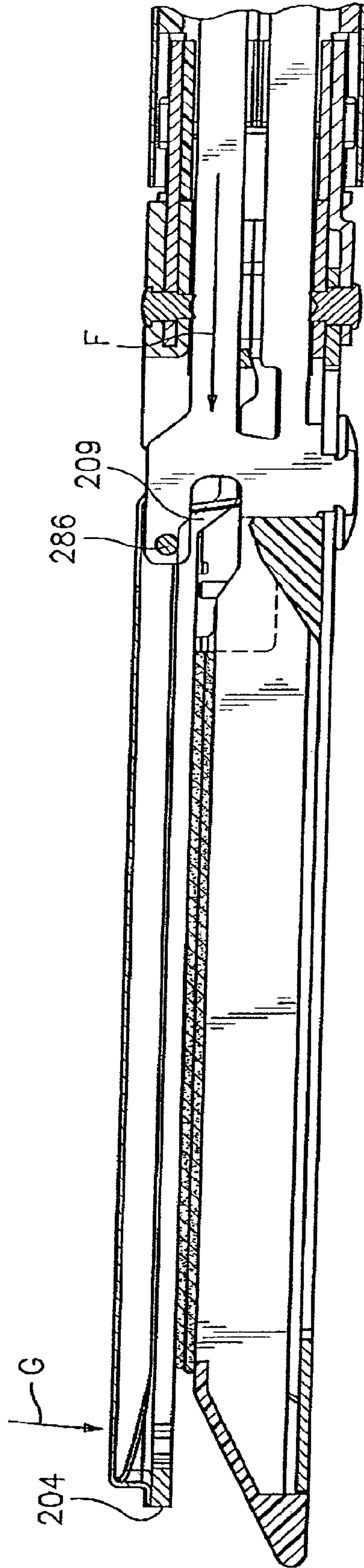


FIG. 49

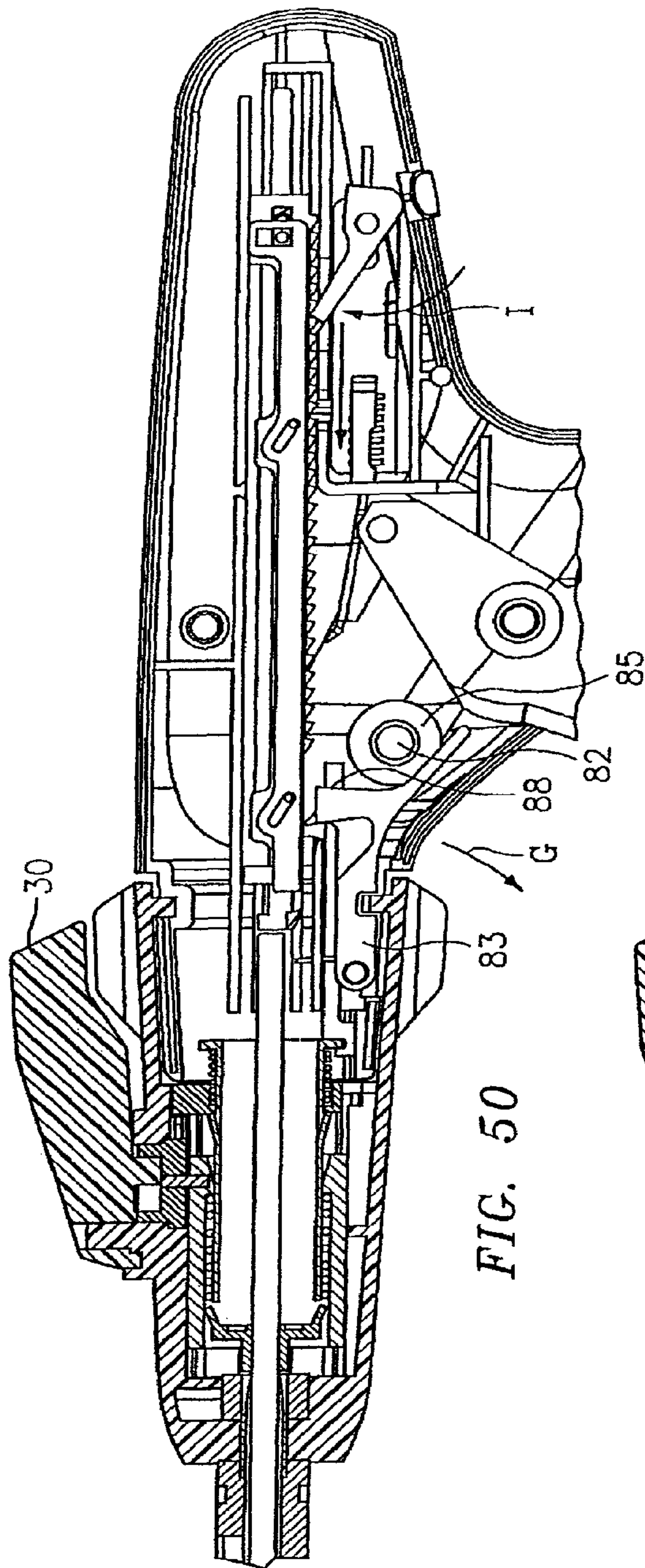


FIG. 50

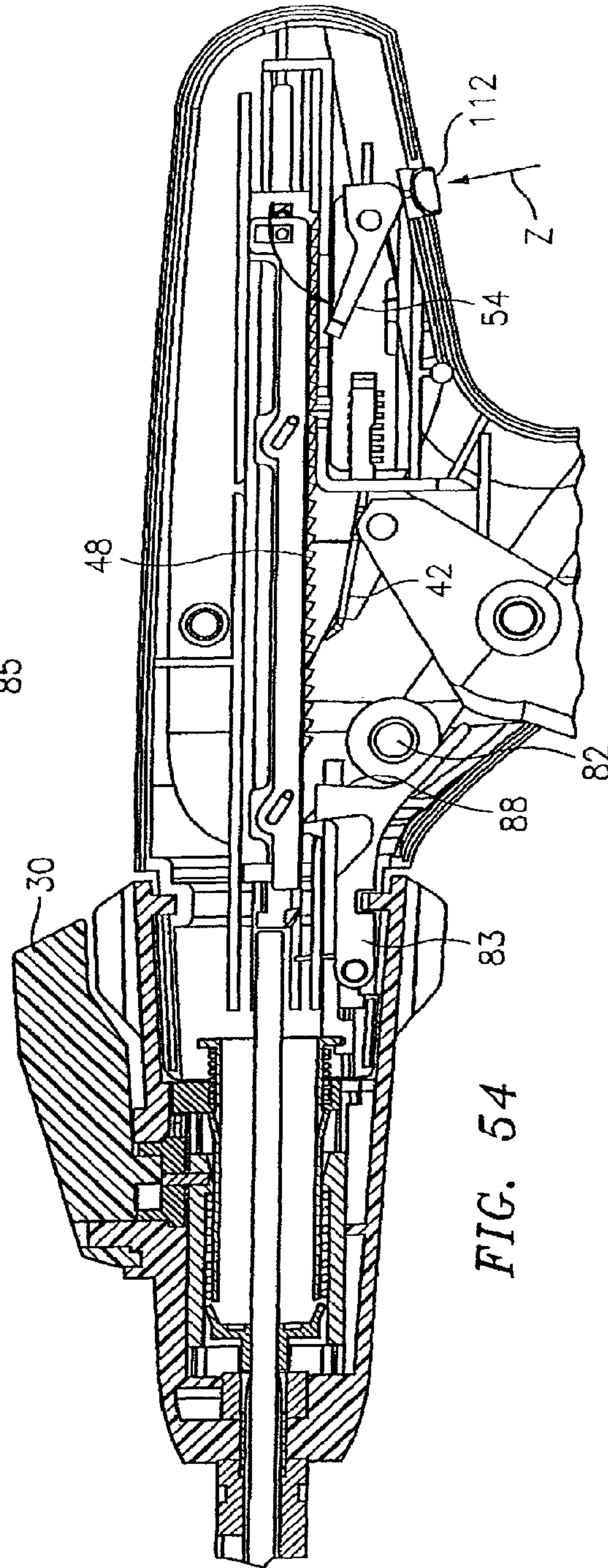


FIG. 54

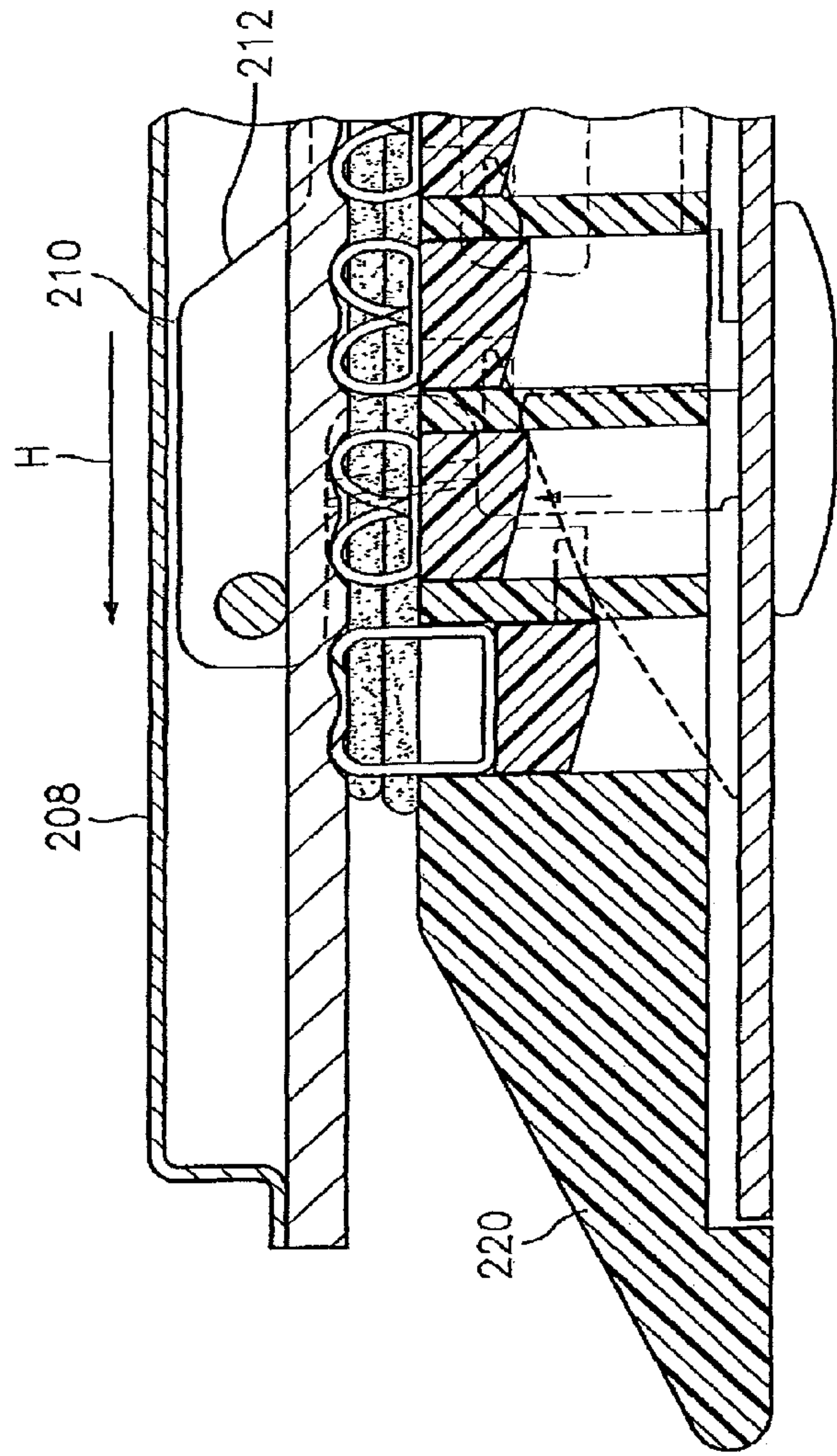


FIG. 51

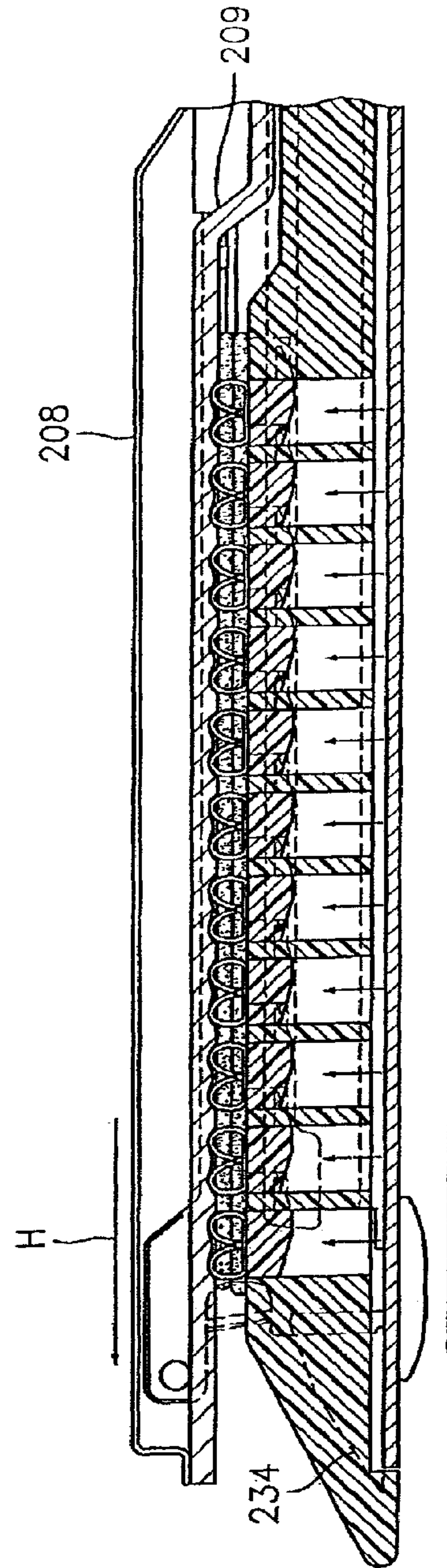


FIG. 52

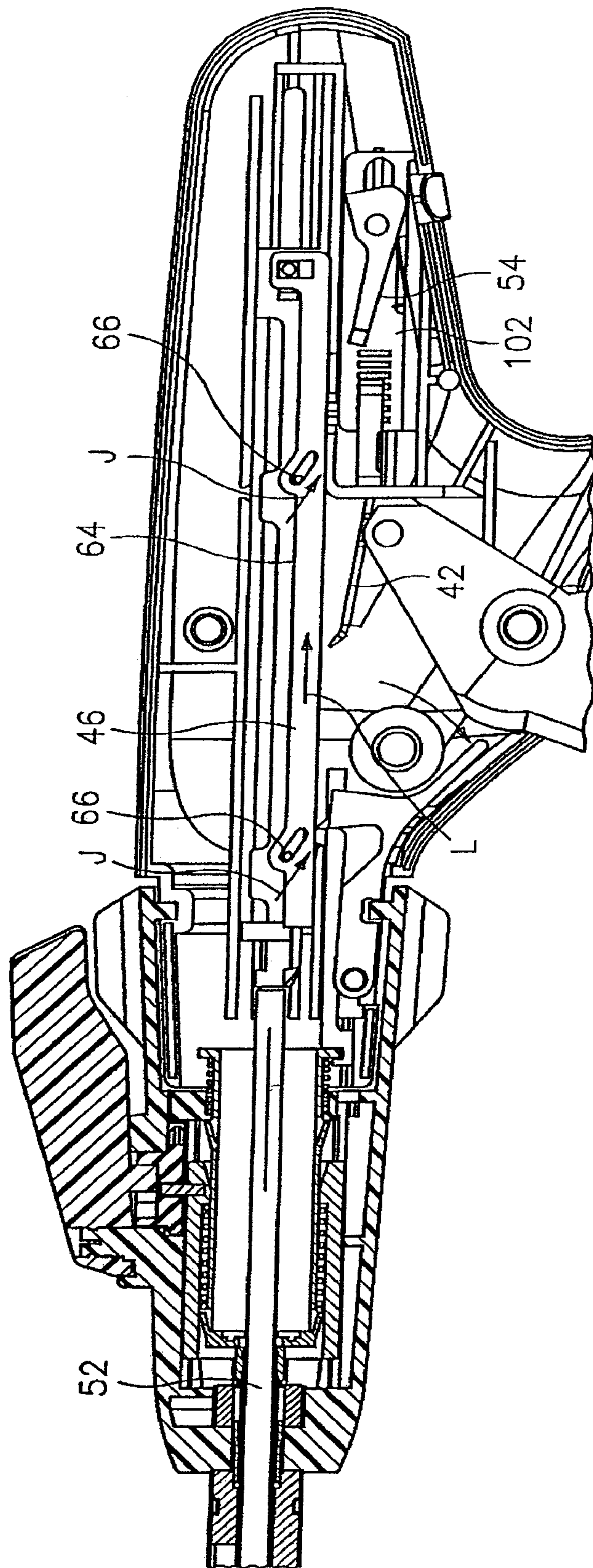


FIG. 53

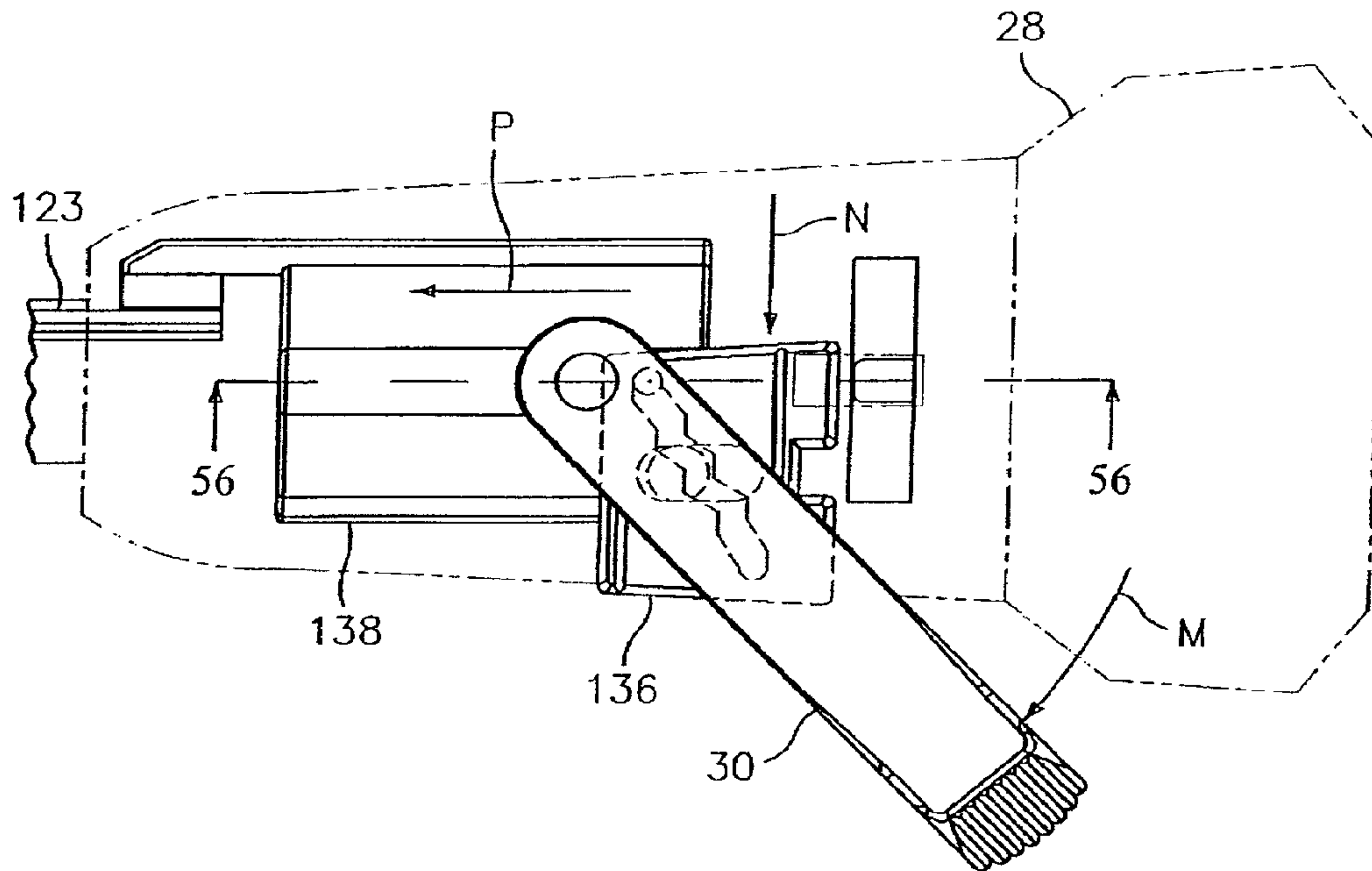


FIG. 55

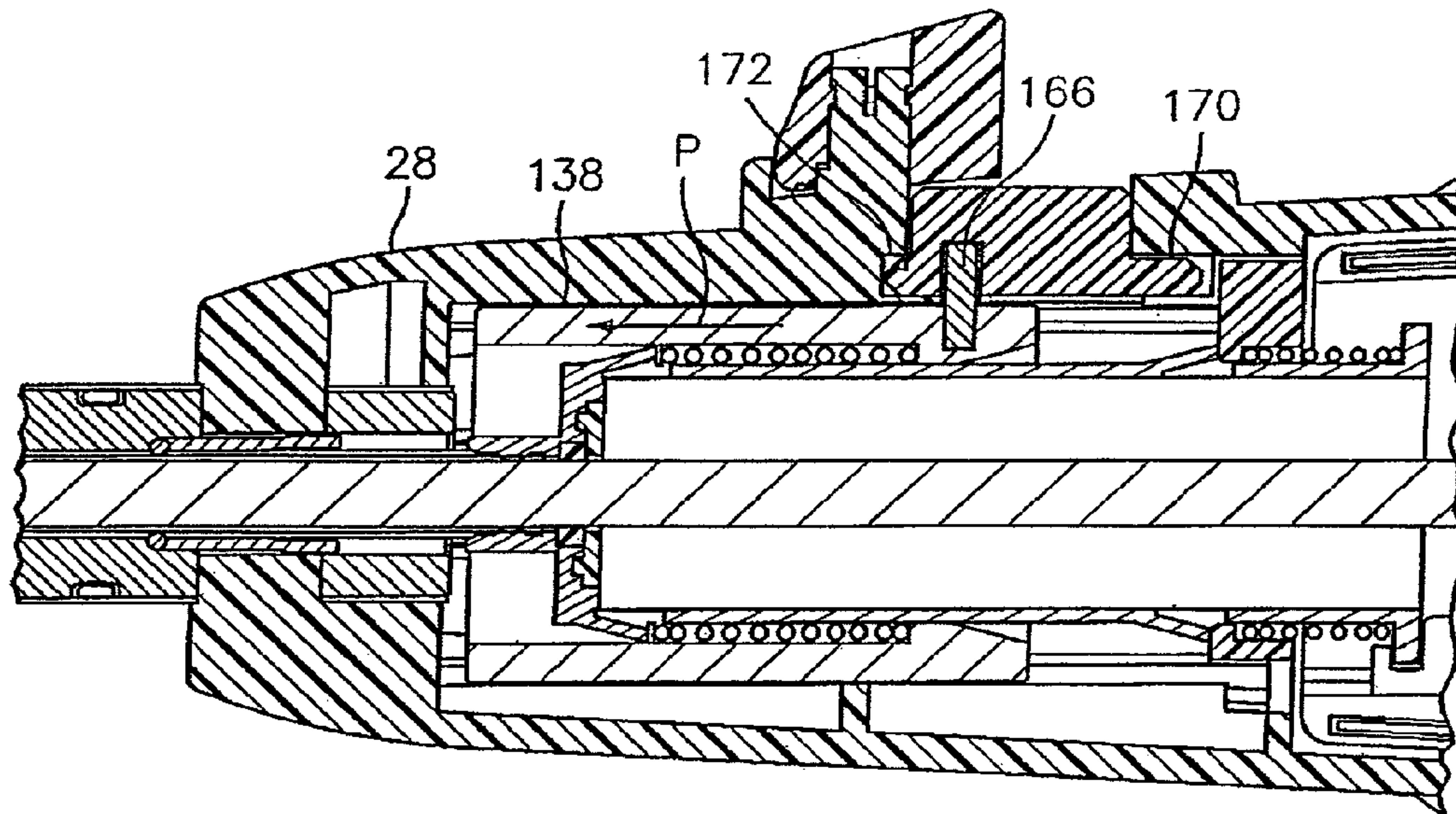


FIG. 56

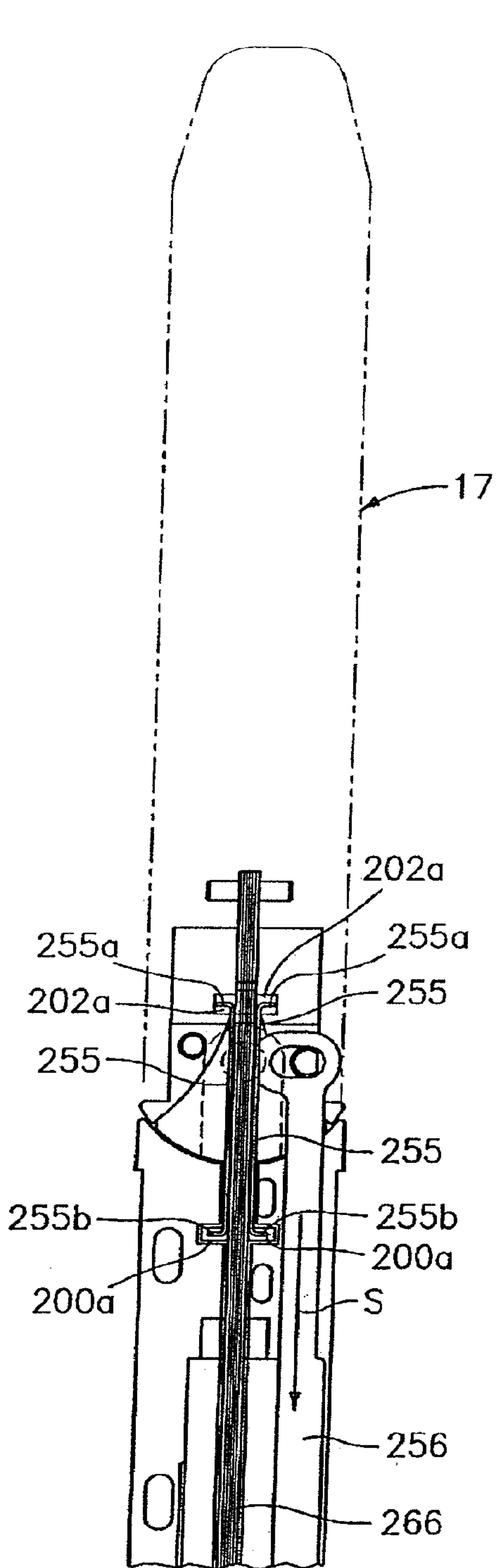


FIG. 57

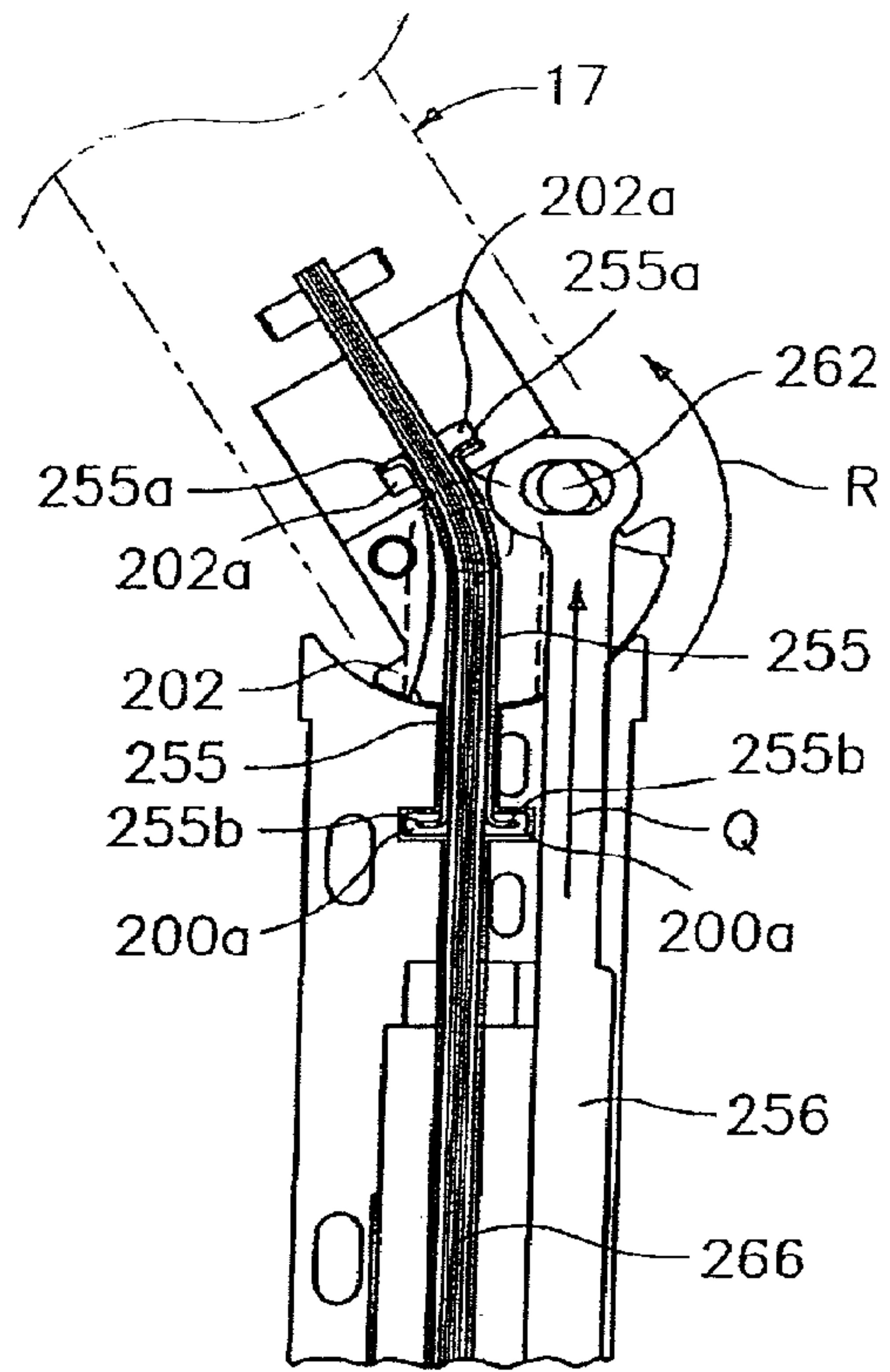


FIG. 60

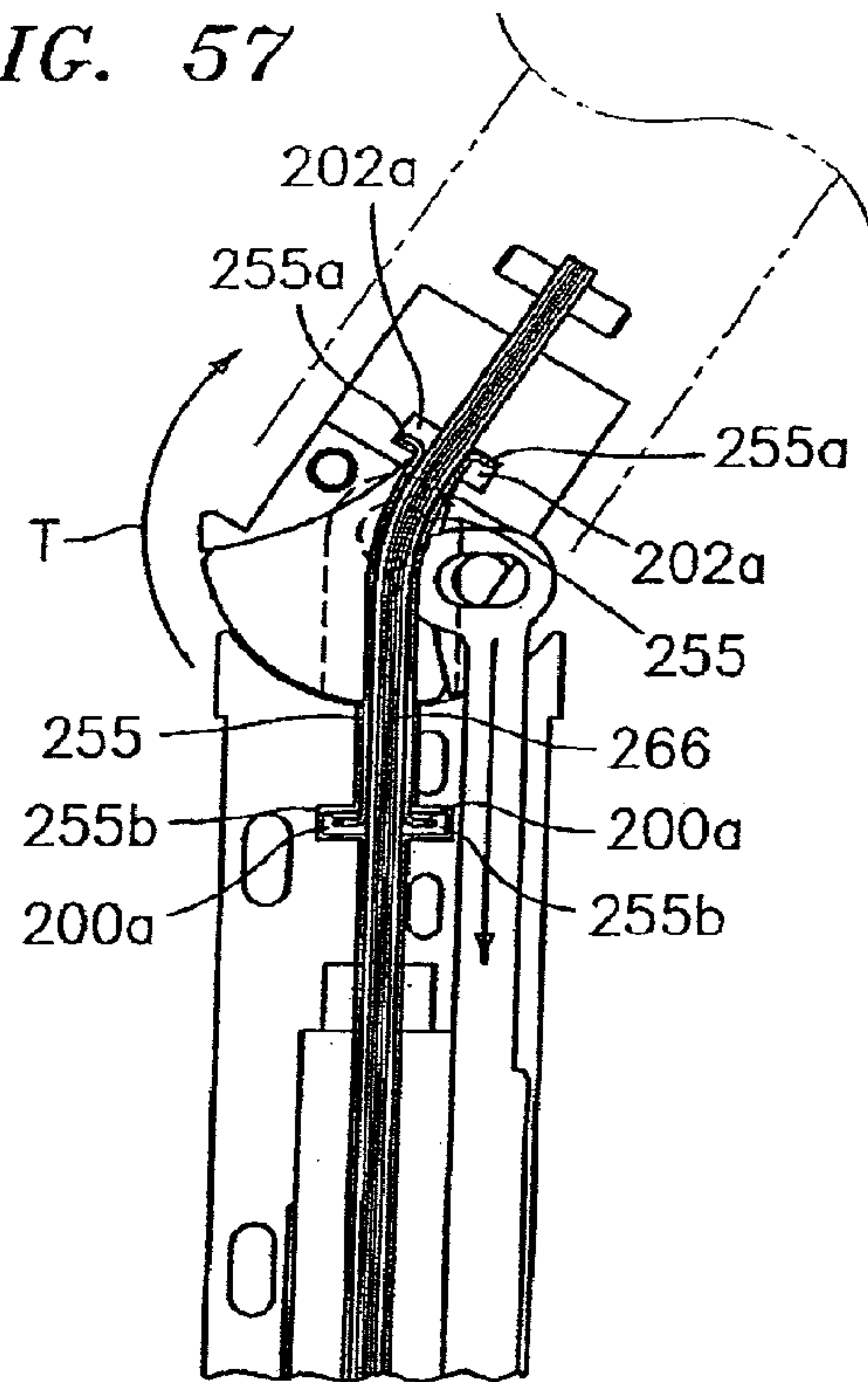
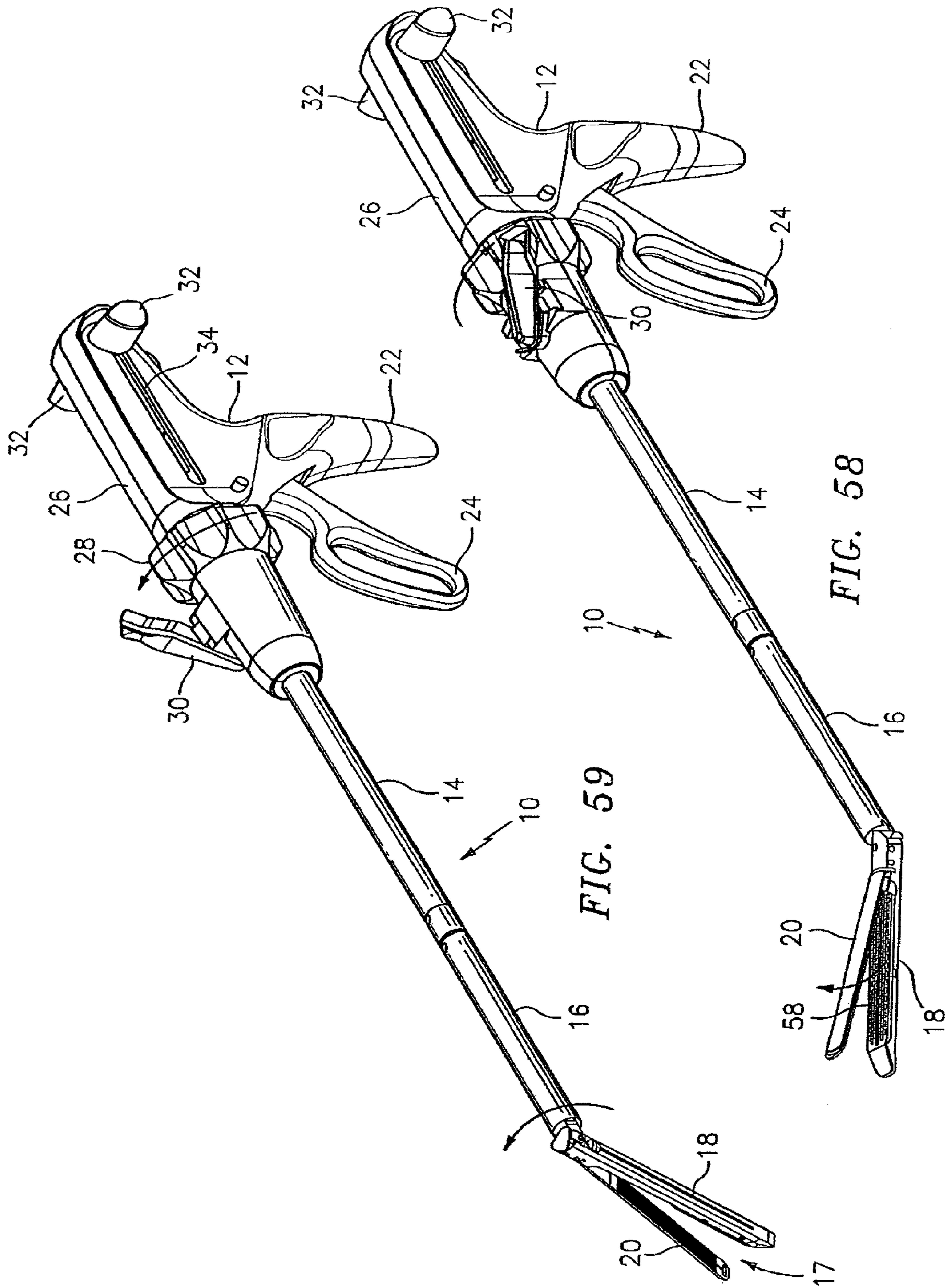


FIG. 61



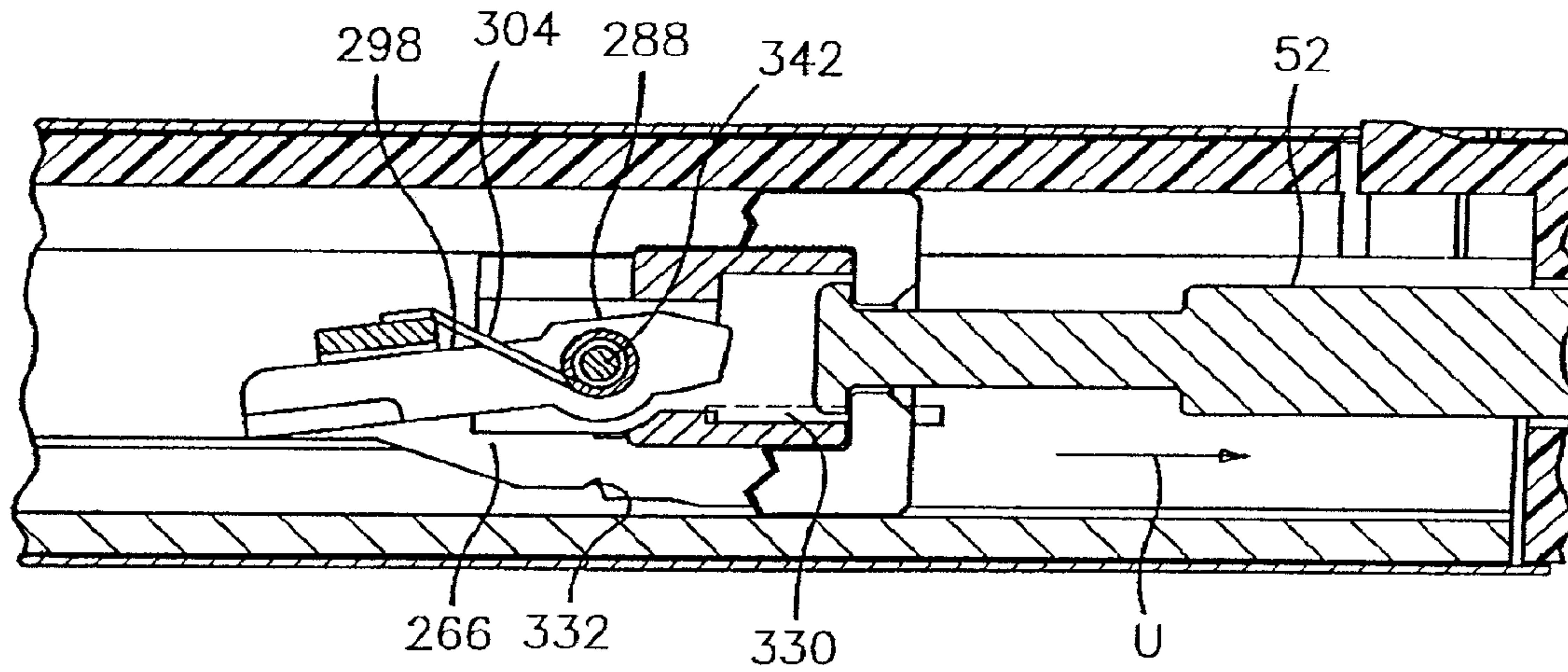


FIG. 62

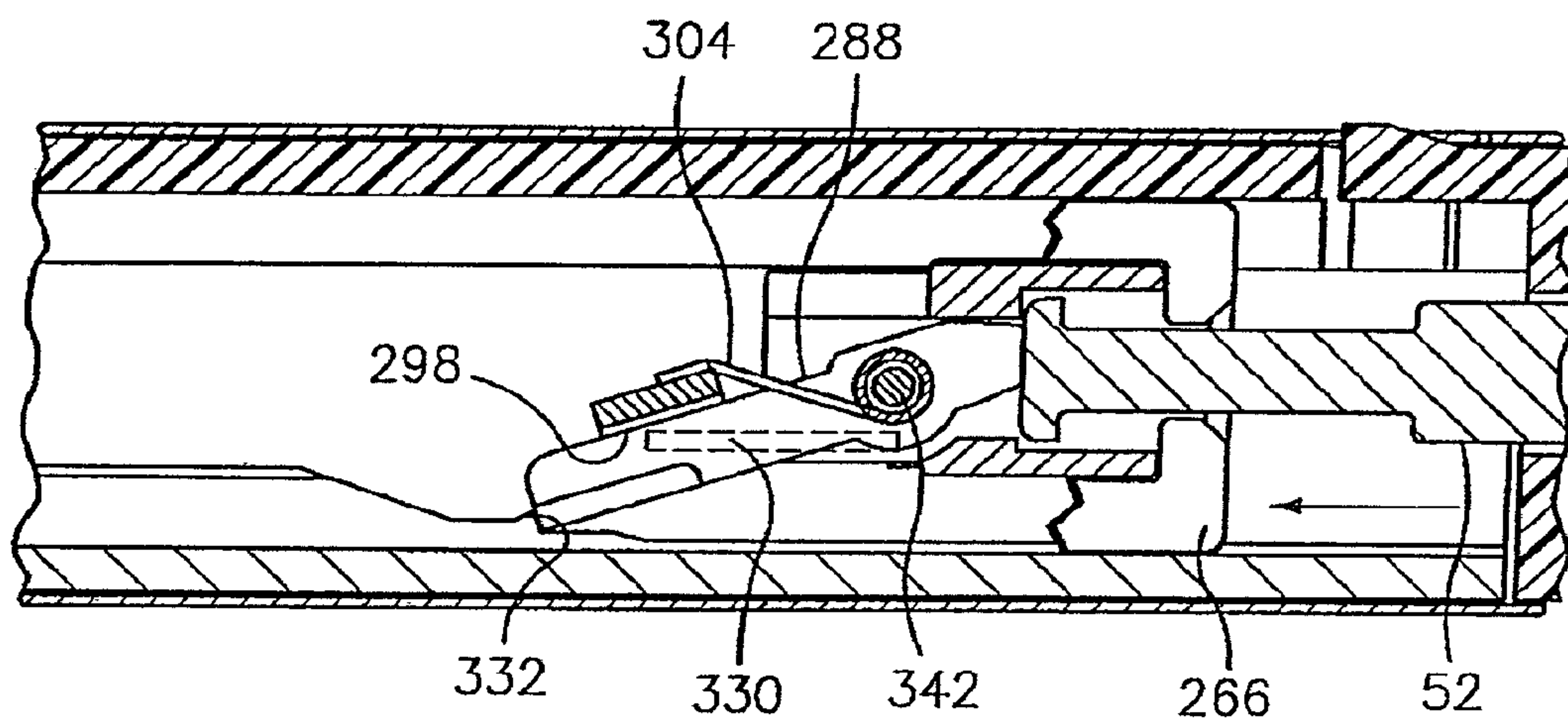


FIG. 63

SURGICAL STAPLING APPARATUS INCLUDING SENSING MECHANISM

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 13,585,350, filed on Aug. 14, 2012, now U.S. Pat. No. 8,342,377 which is a continuation of U.S. patent application Ser. No. 13/491,085, filed on Jun. 7, 2012, now U.S. Pat. No. 8,292,152, which is a continuation of U.S. patent application Ser. No. 13/295,140, filed on Nov. 14, 2011, now U.S. Pat. No. 8,256,656, which is a continuation of U.S. patent application Ser. No. 13/285,355, filed on Oct. 31, 2011, now U.S. Pat. No. 8,210,416, which is a continuation of U.S. patent application Ser. No. 12/793,196, filed on Jun. 3, 2010, now U.S. Pat. No. 8,070,033, which is a continuation of U.S. patent application Ser. No. 12/494,617, filed on Jun. 30, 2009, now U.S. Pat. No. 8,083,118, which is a divisional of U.S. patent application Ser. No. 11/974,638, filed on Oct. 15, 2007, now U.S. Pat. No. 7,565,993, which is a continuation of U.S. patent application Ser. No. 11/489,212, filed on Jul. 19, 2006, now U.S. Pat. No. 7,303,107, which is a continuation of U.S. patent application Ser. No. 11/186,742, filed on Jul. 20, 2005, now abandoned, which is a continuation of U.S. patent application Ser. No. 10/983,288, filed on Nov. 5, 2004, now U.S. Pat. No. 6,953,139, which is a continuation of U.S. patent application Ser. No. 10/700,250, filed on Nov. 3, 2003, now abandoned, which is a continuation of U.S. patent application Ser. No. 10/014,004, filed on Dec. 10, 2001, now U.S. Pat. No. 6,669,073, which is a continuation of U.S. patent application Ser. No. 09/680,093, filed on Oct. 5, 2000, now U.S. Pat. No. 6,330,965, which is a divisional of U.S. patent application Ser. No. 09/561,567, filed on Apr. 28, 2000, now U.S. Pat. No. 6,241,139, which is a divisional of U.S. patent application Ser. No. 09/166,378, filed on Oct. 5, 1998, now U.S. Pat. No. 6,079,606, which is a divisional of U.S. patent application Ser. No. 08/935,980, filed on Sep. 23, 1997, now U.S. Pat. No. 5,865,361. The entire content of each application identified above is hereby incorporated by reference.

BACKGROUND

1. Technical Field

This application relates to a surgical stapling apparatus, and more particularly, to an articulating mechanism for use with an endoscopic surgical stapling apparatus for sequentially applying a plurality of surgical fasteners to body tissue and optionally incising fastened tissue.

2. Background of Related Art

Surgical devices wherein tissue is first grasped or clamped between opposing jaw structure and then joined by surgical fasteners are well known in the art. In some instruments a knife is provided to cut the tissue which has been joined by the fasteners. The fasteners are typically in the form of surgical staples but two part polymeric fasteners can also be utilized.

Instruments for this purpose can include two elongated members which are respectively used to capture or clamp tissue. Typically, one of the members carries a staple cartridge which houses a plurality of staples arranged in at least two lateral rows while the other member has an anvil that defines a surface for forming the staple legs as the staples are driven from the staple cartridge. Generally, the stapling operation is effected by cam bars that travel longitudinally through the staple cartridge, with the cam bars acting upon staple pushers to sequentially eject the staples from the staple cartridge. A knife can travel between the staple rows to longitudinally cut

and/or open the stapled tissue between the rows of staples. Such instruments are disclosed, for example, in U.S. Pat. No. 3,079,606 and U.S. Pat. No. 3,490,675.

A later stapler disclosed in U.S. Pat. No. 3,499,591 applies a double row of staples on each side of the incision. This is accomplished by providing a disposable loading unit in which a cam member moves through an elongate guide path between two sets of staggered staple carrying grooves. Staple drive members are located within the grooves and are positioned in such a manner so as to be contacted by the longitudinally moving cam member to effect ejection of the staples from the staple cartridge of the disposable loading unit. Other examples of such staplers are disclosed in U.S. Pat. Nos. 4,429,695 and 5,065,929.

Each of the instruments described above were designed for use in conventional surgical procedures wherein surgeons have direct manual access to the operative site. However, in endoscopic or laparoscopic procedures, surgery is performed through a small incision or through a narrow cannula inserted through small entrance wounds in the skin. In order to address the specific needs of endoscopic and/or laparoscopic surgical procedures, endoscopic surgical stapling devices have been developed and are disclosed in, for example, U.S. Pat. Nos. 5,040,715 (Green, et al.); 5,307,976 (Olson, et al.); 5,312,023 (Green, et al.); 5,318,221 (Green, et al.); 5,326,013 (Green, et al.); and 5,332,142 (Robinson, et al.).

U.S. Surgical, the assignee of the present application, has manufactured and marketed endoscopic stapling instruments, such as the Multifire ENDO GIA* 30 and Multifire ENDO GIA* 60 instruments, for several years. These instruments have provided significant clinical benefits. Nonetheless, improvements are possible, for example, by reducing the cost and complexity of manufacture.

Current laparoscopic linear stapling devices are configured to operate with disposable loading units (U.S. Surgical) and staple cartridges (Ethicon) of only one size. For example, individual linear staplers are presently available for applying parallel rows of staples measuring 30 mm, 45 mm and 60 mm in length. Thus, during a normal operation, a surgeon may be required to utilize several different stapling instruments to perform a single laparoscopic surgical procedure. Such practices increase the time, complexity and overall costs associated with laparoscopic surgical procedures. In addition, costs are greater in designing and manufacturing multiple stapler sizes, as opposed to creating a single, multipurpose stapler.

It would be extremely beneficial to provide a surgical device for use during laparoscopic and/or endoscopic surgical procedures that can be employed with several different sized disposable loading units to reduce the overall costs associated with such procedures. It would also be particularly beneficial if the device could perform multiple tasks, using disposable loading units of varying size and of varying purpose, such as, for example, to staple, clip, cut and/or articulate.

In making improvements or modifications to the current instruments, it would be highly desirable not to sacrifice any of the important benefits of the MULTIFIRE ENDO GIA* 30 and 60 instruments as compared to other commercially available products, e.g., the endoscopic stapling instruments manufactured and marketed by Ethicon, Inc. For example, any improvement should advantageously provide a fresh knife blade for each firing of the instrument and ensure that the disposable loading unit is securely retained in the stapling instrument unless and until the operating team chooses to remove it. These advantages have historically been found in the U.S. Surgical instruments, but not in the Ethicon instruments.

SUMMARY

In accordance with the present disclosure, a surgical stapling apparatus for sequentially applying a plurality of fasteners to body tissue and simultaneously incising tissue is provided. The surgical stapling apparatus is adapted to receive disposable loading units having rows of staples having a linear length of between 30 mm and 60 mm. The surgical stapling apparatus is also adapted to receive articulating and non-articulating disposable loading units.

The surgical stapling apparatus includes a handle assembly having a movable handle and a stationary handle. The movable handle is movable through an actuation stroke to clamp tissue and to effect ejection of staples from the disposable loading unit. An elongated body extends distally from the handle assembly and defines a longitudinal axis. An actuation shaft having a toothed rack is operably associated with the movable handle by a pawl mechanism. The distal end of the actuation shaft is connected to a control rod having a distal end adapted to operatively engage an axial drive assembly located within a disposable loading unit.

The stapling apparatus includes an articulation mechanism having an articulation lever operatively engaged with a cam member having a stepped camming channel. The cam member is engaged with a translation member which includes a pin dimensioned to be received within the stepped camming channel such that pivotable movement of the lever causes linear movement of the translation member. A first articulation link includes a proximal end adapted to engage the translation member and a distal end adapted to engage a second articulation link positioned within the disposable loading unit. Linear movement of the translation member causes linear movement of the articulation links to cause articulation of a tool assembly of the disposable loading unit.

The surgical stapling apparatus also preferably includes a sensing mechanism for sensing the type of disposable loading unit secured to the elongated body of the apparatus. The sensing mechanism includes a sensing tube positioned within the elongated body to engage a disposable loading unit secured to the elongated body. A sensing cylinder connected to the sensing tube engages a locking ring having a tab portion configured to engage the articulation mechanism in a first position to prevent movement of the articulation lever. The locking ring is moved by the sensing cylinder when an articulating disposable loading unit is secured to the elongated body of the stapling apparatus to a second position to disengage the tab portion from the articulation mechanism to permit movement of the articulation lever. In contrast, a non-articulating disposable loading unit will not unlock the articulation lever.

BRIEF DESCRIPTION OF THE DRAWINGS

Various preferred embodiments are described herein with reference to the drawings:

FIG. 1 is a perspective view of one preferred embodiment of the presently disclosed surgical stapling apparatus;

FIG. 2 is a top view of the surgical apparatus shown in FIG. 1;

FIG. 3 is a side view of the surgical apparatus shown in FIG. 1;

FIG. 4 is a perspective view with parts separated of the handle assembly of the surgical apparatus shown in FIG. 1;

FIG. 5 is a cross-sectional view of a portion of the firing lockout mechanism shown in FIG. 4;

FIG. 6 is a perspective of the slide plate of the anti-reverse clutch mechanism of the surgical apparatus;

FIG. 7 is an enlarged perspective view of the anti-reverse clutch mechanism shown in FIG. 1;

FIG. 8 is a side cross-sectional view of the surgical stapling apparatus shown in FIG. 1 in the non-actuated position with the disposable loading unit removed;

FIG. 9 is a perspective view with parts separated of the rotation member, the articulation mechanism, and the elongated body of the surgical stapling apparatus shown in FIG. 1;

FIG. 10 is an enlarged view of the indicated area of detail shown in FIG. 8;

FIG. 10a is a perspective view of the translation member of the articulation mechanism and the proximal end of the elongated body of the surgical stapling apparatus shown in FIG. 1;

FIG. 10b is an enlarged cross-sectional view of the indicated area of detail of FIG. 8;

FIG. 10c is a cross-sectional view along section line 10c-10c of FIG. 8;

FIG. 11 is a perspective view of the cam member of the articulation mechanism of the surgical stapling apparatus shown in FIG. 1;

FIG. 12 is a top view of the cam member of the articulation mechanism of the surgical stapling apparatus shown in FIG. 1;

FIG. 12a is a perspective view of a non-articulating disposable loading unit usable with the surgical stapling apparatus shown in FIG. 1;

FIG. 12b is a perspective view of the preferred articulating disposable loading unit of the surgical stapling apparatus shown in FIG. 1;

FIG. 13 is a cross-sectional view taken along section line 13-13 of FIG. 10;

FIG. 14 is a cross-sectional view taken along section line 14-14 of FIG. 10;

FIG. 15 is a cross-sectional view taken along section line 15-15 of FIG. 10;

FIG. 16 is an enlarged view of the indicated area of detail shown in FIG. 8;

FIG. 17 is a side perspective view of the blocking plate of the surgical stapling apparatus shown in FIG. 1;

FIG. 18 is a top perspective view of the blocking plate of the surgical stapling apparatus shown in FIG. 1;

FIG. 19 is a perspective view of a disposable loading unit usable with the surgical stapling apparatus of FIG. 1;

FIG. 20 is another perspective view of a disposable loading unit usable with the surgical stapling apparatus of FIG. 1;

FIG. 21 is a perspective view of the tool assembly of the surgical stapling apparatus of FIG. 1 with parts separated;

FIG. 22 is an enlarged perspective view of the distal end of the anvil assembly showing a plurality of staple deforming cavities;

FIG. 23 is an enlarged perspective view of the distal end of the staple cartridge of the surgical stapling apparatus shown in FIG. 1;

FIG. 24 is a side cross-sectional view taken along section line 24-24 of FIG. 23;

FIG. 25 is a bottom perspective view of the staple cartridge shown in FIG. 21;

FIG. 26 is an enlarged perspective view of the actuation sled, the pushers and the fasteners shown in FIG. 21;

FIG. 27 is an enlarged perspective view with parts separated of the proximal housing portion and mounting assembly of the disposable loading unit shown in FIG. 19;

FIG. 28 is an enlarged perspective view of the mounting assembly of the disposable loading unit shown in FIG. 19 mounted to a distal end portion of the proximal housing portion;

5

FIG. 29 is an enlarged perspective view of the proximal housing portion and the mounting assembly of the disposable loading unit shown in FIG. 19 with the upper housing half removed;

FIG. 30 is a perspective view of the proximal housing portion and the mounting assembly of the disposable loading unit shown in FIG. 19 with the upper housing half removed;

FIG. 31 is a perspective view with parts separated of the axial drive assembly;

FIG. 32 is an enlarged perspective view of the axial drive assembly shown in FIG. 31;

FIG. 33 is an enlarged perspective view of the proximal end of the axial drive assembly shown in FIG. 31 including the locking device;

FIG. 34 is an enlarged perspective view of the distal end of the axial drive assembly shown in FIG. 31;

FIG. 35 is an enlarged perspective view of the distal end of the elongated body of the stapling apparatus shown in FIG. 1;

FIG. 36 is an enlarged perspective view of the locking device shown in FIG. 33;

FIG. 37 is an enlarged perspective view of a lower housing half of the proximal housing portion of the disposable loading unit shown in FIG. 27;

FIG. 38 is a side cross-sectional view of the disposable loading unit shown in FIG. 20;

FIG. 39 is an enlarged view of the indicated area of detail shown in FIG. 38;

FIG. 40 is a perspective view of the surgical stapling apparatus shown in FIG. 1 with the disposable loading unit of FIG. 19 detached from the elongated body;

FIG. 41 is an enlarged perspective view of the disposable loading unit of FIG. 19 during attachment to the elongated body of the surgical stapling apparatus shown in FIG. 1;

FIG. 42 is another enlarged perspective view of the disposable loading unit of FIG. 19 during attachment to the elongated body of the surgical stapling apparatus shown in FIG. 1;

FIG. 43 is a cross-sectional view taken along section line 43-43 of FIG. 41;

FIG. 43a is a side cross-sectional view of the rotation knob, articulation mechanism, and sensing mechanism during insertion of a disposable loading unit into the elongated body of the surgical stapling apparatus;

FIG. 44 is a cross-sectional view taken along section line 44-44 of FIG. 42;

FIG. 45 is a side cross-sectional view of the distal end of the disposable loading unit of FIG. 1 with tissue positioned between the anvil and clamp assemblies;

FIG. 46 is a side cross-sectional view of the handle assembly with the movable handle in an actuated position;

FIG. 47 is an enlarged view of the indicated area of detail shown in FIG. 46;

FIG. 48 is a cross-sectional view of the proximal end of the disposable loading unit of FIG. 19 and the distal end of the elongated body of the surgical stapling apparatus shown in FIG. 1 with the control rod in a partially advanced position;

FIG. 49 is a cross-sectional view of the tool assembly of the surgical stapling apparatus shown in FIG. 1 positioned about tissue in the clamped position;

FIG. 50 is a cross-sectional view of the handle assembly of the stapling apparatus of FIG. 1 during the clamping stroke of the apparatus;

FIG. 51 is a side cross-sectional view of the distal end of the tool assembly of the stapling apparatus shown in FIG. 1 during firing of the apparatus;

FIG. 52 is a side cross-sectional view of the distal end of the tool assembly of the stapling apparatus shown in FIG. 1 after firing of the apparatus;

6

FIG. 53 is a side cross-sectional view of the handle assembly of the apparatus during retraction of the actuation shaft;

FIG. 54 is a side cross-sectional view of the handle assembly of the stapling apparatus during actuation of the emergency release button;

FIG. 55 is a top view of the articulation mechanism of the surgical stapling apparatus;

FIG. 56 is a side cross-sectional view of the articulation mechanism and rotation member of the surgical stapling apparatus shown in FIG. 1;

FIG. 57 is a top view of the distal end of the elongated body, the mounting assembly, and the proximal end of the tool assembly during articulation of the stapling apparatus;

FIG. 58 is a perspective view of the surgical stapling apparatus during articulation of the tool assembly;

FIG. 59 is a perspective view of the surgical stapling apparatus during articulation and rotation of the tool assembly;

FIG. 60 is a top view of the distal end of the disposable loading unit immediately prior to articulation;

FIG. 61 is a top view of the distal end of the elongated body, the mounting assembly, and the proximal end of the tool assembly during articulation of the stapling apparatus;

FIG. 62 is a partial cross-sectional view of a portion of the disposable loading unit during retraction of the locking device; and

FIG. 63 is a partial cross-sectional view of a portion of the disposable loading unit with the locking device in the locked position.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Preferred embodiments of the presently disclosed endoscopic surgical stapling apparatus will now be described in detail with reference to the drawings, in which like reference numerals designate identical or corresponding elements in each of the several views.

In the drawings and in the description that follows, the term "proximal", as is traditional, will refer to the end of the stapling apparatus which is closest to the operator, while the term distal will refer to the end of the apparatus which is furthest from the operator.

FIGS. 1-3 illustrate one embodiment of the presently disclosed surgical stapling apparatus shown generally as 10. Briefly, surgical stapling apparatus 10 includes a handle assembly 12 and an elongated body 14. A disposable loading unit or DLU 16 is releasably secured to a distal end of elongated body 14. Disposable loading unit 16 includes a tool assembly 17 having a cartridge assembly 18 housing a plurality of surgical staples and an anvil assembly 20 movably secured in relation to cartridge assembly 18. Disposable loading unit 16 is configured to apply linear rows of staples measuring from about 30 mm to about 60 mm in length. Disposable loading units having linear rows of staples of other lengths are also envisioned, e.g., 45 mm. Handle assembly 12 includes a stationary handle member 22, a movable handle member 24, and a barrel portion 26. A rotatable member 28 is preferably mounted on the forward end of barrel portion 26 to facilitate rotation of elongated body 14 with respect to handle assembly 12. An articulation lever 30 is also preferably mounted on the forward end of barrel portion 26 adjacent rotatable knob 28 to facilitate articulation of tool assembly 17. A pair of retraction knobs 32 are movably positioned along barrel portion 26 to return surgical stapling apparatus 10 to a retracted position, as will be described in detail below.

Referring to FIG. 4, handle assembly 12 includes housing 36, which is preferably formed from molded housing half-sections 36a and 36b, which forms stationary handle member 22 and barrel portion 26 of handle assembly 12 (See FIG. 1). Movable handle member 24 is pivotably supported between housing half-sections 36a and 36b about pivot pin 38. A biasing member 40, which is preferably a torsion spring, biases movable handle 24 away from stationary handle 22. An actuation shaft 46 is supported within barrel portion 26 of housing 36 and includes a toothed rack 48. A driving pawl 42 having a rack engagement finger 43 with laterally extending wings 43a and 43b is pivotably mounted to one end of movable handle 24 about a pivot pin 44. A biasing member 50, which is also preferably a torsion spring, is positioned to urge engagement finger 43 of driving pawl 42 towards toothed rack 48 of actuation shaft 46. Movable handle 24 is pivotable to move engagement finger 43 of driving pawl 42 into contact with toothed rack 48 of actuation shaft 46 to advance the actuation shaft linearly in the distal direction. The forward end of actuation shaft 46 rotatably receives the proximal end 49 of a control rod 52 such that linear advancement of actuation shaft 46 causes corresponding linear advancement of control rod 52. A locking pawl 54 having a rack engagement member 55 is pivotably mounted within housing 36 about pivot pin 57 and is biased towards toothed rack 48 by biasing member 56, which is also preferably a torsion spring. Engagement member 55 of locking pawl 54 is movable into engagement with toothed rack 48 to retain actuation shaft 46 in a longitudinally fixed position.

A retraction mechanism 58 which includes a pair of retractor knobs 32 (See FIG. 1) is connected to the proximal end of actuation shaft 46 by a coupling rod 60. Coupling rod 60 includes right and left engagement portions 62a and 62b for receiving retractor knobs 32 and a central portion 62c which is dimensioned and configured to translate within a pair of longitudinal slots 34a formed in actuation shaft 46 adjacent the proximal end thereof. A release plate 64 is operatively associated with actuation shaft 46 and is mounted for movement with respect thereto in response to manipulation of retractor knobs 32. A pair of spaced apart pins 66 extend outwardly from a lateral face of actuation shaft 46 to engage a pair of corresponding angled cam slots 68 formed in release plate 64. Upon rearward movement of retractor knobs 32, pins 66 can release plate 64 downwardly with respect to actuation shaft 46 and with respect to toothed rack 48 such that the bottom portion of release plate 64 extends below toothed rack 48 to disengage engagement finger 43 of driving pawl 42 from toothed rack 48. A transverse slot 70 is formed at the proximal end of release plate 64 to accommodate the central portion 62c of coupling rod 60, and elongated slots 34 (See FIG. 1) are defined in the barrel section 26 of handle assembly 12 to accommodate the longitudinal translation of coupling rod 60 as retraction knobs 32 are pulled rearwardly to retract actuation shaft 46 and thus retract control rod 52 rearwardly. Actuation shaft 46 is biased proximally by spring 72 which is secured at one end to coupling rod portion 62 via connector 74 and at the other end to post 76 on actuation shaft 46.

Referring also to FIG. 5, handle assembly 12 includes a firing lockout assembly 80 which includes a plunger 82 and a pivotable locking member 83. Plunger 82 is biased to a central position by biasing springs 84 and includes, annular tapered camming surfaces 85. Each end of plunger 82 extends through housing 36 (See FIG. 1) adjacent an upper end of stationary handle 22. Pivotable locking member 83 is pivotably attached at its distal end between housing half-sections 36a and 36b about pivot pin 86 and includes a locking surface

88 and proximal extension 90 having a slot 89 formed therein. Locking member 83 is biased by spring 92 counter-clockwise (as viewed in FIG. 4) to move locking surface 88 to a position to abut the distal end of actuation shaft 46 to prevent advancement of shaft 46 and subsequent firing of stapling apparatus 10. Annular tapered camming surface 85 is positioned to extend into tapered slot 89 in proximal extension 90. Lateral movement of plunger 82 in either direction against the bias of either spring 84 moves tapered camming surface 85 into engagement with the sidewalls of tapered slot 89 to pivot locking member 83 clockwise about pivot pin 86, as viewed in FIG. 4, to move blocking surface 88 to a position to permit advancement of actuation shaft 46 and thus firing of stapling apparatus 10. Blocking surface 88 is retained in this position by recesses 87 which receive the tapered tip of camming surface 85 to lock locking member 83 in a counter-clockwise position. Operation of firing lockout assembly 80 will be further illustrated below.

Referring to FIGS. 4, 6, and 7, handle mechanism 12 also includes an anti-reverse clutch mechanism which includes a first gear 94 rotatably mounted on a first shaft 96, and second gear 98 mounted on a second shaft 100, and a slide plate 102 (FIGS. 6 and 7) slidably mounted within housing 36. Slide plate 102 includes an elongated slot 104 dimensioned and configured to be slidably positioned about locking pawl pivot pin 57, a gear plate 106 configured to mesh with the teeth of second gear 98, and a cam surface 108. In the retracted position, cam surface 108 of slide plate 102 engages locking pawl 54 to prevent locking pawl 54 from engaging toothed rack 48. Actuation shaft 46 includes a distal set of gear teeth 110a spaced from a proximal set of gear teeth 110b positioned to engage first gear 94 of actuation shaft 46 during movement of actuation shaft 46. When actuation shaft 46 is advanced by pivoting movable handle 24 about pivot pin 38, distal gear teeth 110a on actuation shaft 46 mesh with and rotate first gear 94 and first shaft 96. First shaft 96 is connected to second shaft 100 by spring clutch assembly such that rotation of first shaft 96 will cause corresponding rotation of second shaft 100. Rotation of second shaft 100 causes corresponding rotation of second gear 98 which is engaged with gear plate 106 on slide plate 102 to cause linear advancement of slide plate 102. Linear advancement of slide plate 102 is limited to the length of elongated slot 104. When slide plate has been advanced the length of slot 104, cam surface 108 releases locking pawl 54 such that it is moved into engagement with toothed rack 48. Continued advancement of actuation shaft 46 eventually moves gear teeth 110b into engagement with gear plate 106. However, since slide plate 102 is longitudinally fixed in position, the spring clutch is forced to release, such that continued distal advancement of actuation shaft 46 is permitted.

When actuation shaft 46 is returned to the retracted position (by pulling retraction knobs 34 proximally, as discussed above) gear teeth 110b engage first gear 94 to rotate second gear 98 in the reverse direction to retract slide member 102 proximally within housing 36. Proximal movement of slide member 102 advances cam surface 108 into locking pawl 54 prior to engagement between locking pawl 54 and toothed rack 48 to urge locking pawl 54 to a position to permit retraction of actuation shaft 46.

Referring again to FIG. 4, handle assembly 12 includes an emergency return button 112 pivotally mounted within housing 36 about a pivot member 114 supported between housing half-sections 36a and 36b. Return button 112 includes an externally positioned member 116 positioned on the proximal end of barrel portion 26. Member 116 is movable about pivot member 114 into engagement with the proximal end of lock-

ing pawl **54** to urge rack engagement member **55** out of engagement with toothed rack **48** to permit retraction of actuation shaft **46** during the firing stroke of the stapling apparatus **10**. As discussed above, during the clamping portion of advancement of actuation shaft **46**, slide plate **102** disengages pawl **54** from rack **48** and thus actuation of return button **112** is not necessary to retract the actuation shaft **46**.

FIG. **8** illustrates the interconnection of elongated body **14** and handle assembly **12**. Referring to FIGS. **8-10**, housing **36** includes an annular channel **117** configured to receive an annular rib **118** formed on the proximal end of rotation member **28**, which is preferably formed from molded half-sections **28a** and **28b**. Annular channel **117** and rib **118** permit relative rotation between rotation member **28** and housing **36**. Elongated body **14** includes inner housing **122** and an outer casing **124**. Inner housing **122** is dimensioned to be received within outer casing **124** and includes an internal bore **126** (FIG. **8**) which extends therethrough and is dimensioned to slidably receive a first articulation link **123** and control rod **52**. The proximal end of housing **122** and casing **124** each include a pair of diametrically opposed openings **130** and **128**, respectively, which are dimensioned to receive radial projections **132** formed on the distal end of rotation member **28**. Projections **132** and openings **128** and **130** fixedly secure rotation member **28** and elongated body **14** in relation to each other, both longitudinally and rotatably. Rotation of rotation knob **28** with respect to handle assembly **12** thus results in corresponding rotation of elongated body **14** with respect to handle assembly **12**.

An articulation mechanism **120** is supported on rotatable member **28** and includes articulation lever **30**, a cam member **136**, a translation member **138**, and first articulation link **123** (FIG. **9**). Articulation lever **30** is pivotably mounted about pivot member **140** which extends outwardly from rotation member **28** and is preferably formed integrally therewith. A projection **142** extends downwardly from articulation lever **30** for engagement with cam member **136**.

Referring temporarily to FIGS. **11** and **12**, cam member **136** includes a housing **144** having an elongated slot **146** extending through one side thereof and a stepped camming surface **148** formed in the other side thereof. Each step of camming surface **148** corresponds to a particular degree of articulation of stapling apparatus **10**. Although five steps are illustrated, fewer or more steps may be provided. Elongated slot **146** is configured to receive projection **142** formed on articulation lever **30**. Housing **144** includes a distal stepped portion **150** and a proximal stepped portion **152**. Proximal stepped portion **152** includes a recess **154**.

Referring again to FIGS. **8-10** and also to FIGS. **13-15**, translation member **138** includes a plurality of ridges **156** which are configured to be slidably received within grooves **158** formed along the inner walls of rotation member **28**. Engagement between ridges **156** and grooves **158** prevent relative rotation of rotation member **28** and translation member **138** while permitting relative linear movement. The distal end of translation member **138** includes arm **160** which includes an opening **162** configured to receive a finger **164** extending from the proximal end of articulation link **123** (See FIG. **10a**). A pin **166** having a housing **168** constructed from a non-abrasive material, e.g., teflon, is secured to translation member **138** and dimensioned to be received within stepped camming surface **148**.

In an assembled condition, proximal and distal stepped portions **150** and **152** of cam member **136** are positioned beneath flanges **170** and **172** formed on rotation member **28** to restrict cam member **136** to transverse movement with respect to the longitudinal axis of stapling apparatus **10**.

When articulation lever **30** is pivoted about pivot member **140**, cam member **136** is moved transversely on rotation member **28** to move stepped camming surface **148** transversely relative to pin **166**, forcing pin **166** to move proximally or distally along stepped cam surface **148**. Since pin **166** is fixedly attached to translation member **138**, translation member **138** is moved proximally or distally to effect corresponding proximal or distal movement of first articulation link **123**.

Referring to FIGS. **8-10** and **16**, a disposable loading unit sensing mechanism extends within stapling apparatus **10** from elongated body **14** into handle assembly **12**. The sensing mechanism includes a sensor tube **176** which is slidably supported within bore **26** of elongated body **14**. The distal end of sensor tube **176** is positioned towards the distal end of elongated body **14** and the proximal end of sensor tube **176** is secured within the distal end of a sensor cylinder **178** via a pair of nubs **180**. The distal end of a sensor link **182** is secured to the proximal end of sensor cylinder **178**. Sensor link **182** (See FIGS. **8a** and **8c**) has a bulbous end **184** which engages a camming surface **83a** on pivotable locking member **83**. When a disposable loading unit (not shown) is inserted in the distal end of elongated body **14**, the disposable loading unit engages the distal end **177** of sensor tube **176** to drive sensor tube **176** proximally, and thereby drive sensor cylinder **178** and sensor link **182** proximally. Movement of sensor link **182** proximally causes bulbous end **184** of sensor link **182** to move distally of camming surface **83a** to allow locking member **83** to pivot under the bias of spring **92** from a position permitting firing of stapling apparatus **10** to a blocking position, wherein blocking member **83** is positioned to engage actuation shaft **46** and prevent firing of stapling apparatus **10**. Sensor link **182** and locking member **83** function to prevent firing of surgical stapling apparatus **10** after a disposable loading unit has been secured to elongated body **14**, without first operating firing lockout assembly **80**. It is noted that movement of link **182** proximally permits locking member **83** to move to its position shown in FIG. **5**.

Referring again to FIGS. **9-12**, cam member **136** includes recess **154**. A locking ring **184** having a nub portion **186** configured to be received within recess **154** is positioned about sensor cylinder **178** between a control tab portion **188** and a proximal flange portion **190**. A spring **192** positioned between flange portion **190** and locking ring **184** urges locking ring distally about sensor cylinder **178**. When an articulating disposable loading unit **16b** having an extended insertion tip **193** is inserted into the distal end of elongated body **14** of stapling apparatus **10**, insertion tip **193** causes tab portion **188** to move proximally into engagement with locking ring **184** to urge locking ring **184** and nub **186** proximally of recess **154** in cam member **136** (See FIG. **12b**). With nub **186** positioned proximally of recess **154**, cam member **136** is free to move transversely to effect articulation of stapling apparatus **10**. A non-articulating disposable loading unit does not have an extended insertion tip (See FIG. **12a**). As such, when a non-articulating disposable loading unit is inserted in elongated body **14**, sensor cylinder **178** is not retracted proximally a sufficient distance to move nub **186** from recess **154**. Thus, cam member **136** is prevented from moving transversely by nub **186** of locking ring **184** which is positioned in recess **154** and articulation lever **30** is locked in its central position.

Referring to FIGS. **16-18**, the distal end of elongated body **14** includes a control rod locking mechanism **190** which is activated during insertion of a disposable loading unit into elongated body **14**. Control rod locking mechanism **190** includes a blocking plate **192** which is biased distally by a spring **194** and includes a proximal finger **189** having angled

cam surface 195. A semi-circular engagement member 196 is biased transversely towards control rod 52 by a spring 197. Control rod 52 includes an annular recess 199 configured to receive engagement member 196. Blocking plate 192 is movable from a distal position spaced from engagement member 196 to a proximal position located behind engagement member 196. In the proximal position, engagement member 196 is prevented from being biased from recess 199 by engagement with blocking plate 192. During insertion of a disposable loading unit 16 (See FIG. 1) into the distal end of elongated body 14, as will be described in further detail below, cam surface 195 of blocking plate 192 is engaged by a nub 254 (FIG. 30) on the disposable loading unit 16 as the disposable loading unit is rotated into engagement with elongated body 14 to urge plate 192 to the proximal position. Engagement member 196, which is positioned within recess 199, is retained therein by blocking plate 192 while nub 254 engages cam surface 195 to prevent longitudinal movement of control rod 52 during assembly. When the disposable loading unit 16 is properly positioned with respect to the elongated body 14, nub 254 on the proximal end of the disposable loading unit 16 passes off cam surface 195 allowing spring 194 to return blocking plate 192 to its distal position to permit subsequent longitudinal movement of control rod 52. It is noted that when the disposable loading unit nub passes off cam surface 195, an audible clicking sound is produced indicating that the disposable loading unit 16 is properly fastened to the elongated body 14.

Referring to FIGS. 19 and 20, disposable loading unit 16 includes a proximal housing portion 200 adapted to releasably engage the distal end of body portion 14 (FIG. 1). A mounting assembly 202 is pivotally secured to the distal end of housing portion 200, and is configured to receive the proximal end of tool assembly 17 such that pivotal movement of mounting assembly 202 about an axis perpendicular to the longitudinal axis of housing portion 200 effects articulation of tool assembly 17.

Referring to FIGS. 21-26, tool assembly 17 preferably includes anvil assembly 20 and cartridge assembly 18. Anvil assembly 20 includes anvil portion 204 having a plurality of staple deforming concavities 206 (FIG. 22) and a cover plate 208 secured to a top surface of anvil portion 204 to define a cavity 210 (FIG. 24) therebetween. Cover plate 208 is provided to prevent pinching of tissue during clamping and firing of stapling apparatus 10. Cavity 210 is dimensioned to receive a distal end of an axial drive assembly 212 (See FIG. 27). A longitudinal slot 214 extends through anvil portion 204 to facilitate passage of retention flange 284 of axial drive assembly 212 into the anvil cavity 210. A camming surface 209 formed on anvil portion 204 is positioned to engage axial drive assembly 212 to facilitate clamping of tissue 198. A pair of pivot members 211 formed on anvil portion 204 are positioned within slots 213 formed in carrier 216 to guide the anvil portion between the open and clamped positions. A pair of stabilizing members 215 engage a respective shoulder 217 formed on carrier 216 to prevent anvil portion 204 from sliding axially relative to staple cartridge 220 as camming surface 209 is deformed.

Cartridge assembly 18 includes a carrier 216 which defines an elongated support channel 218. Elongated support channel 218 is dimensioned and configured to receive a staple cartridge 220. Corresponding tabs 222 and slots 224 formed along staple cartridge 220 and elongated support channel 218 function to retain staple cartridge 220 within support channel 218. A pair of support struts 223 formed on staple cartridge

220 are positioned to rest on side walls of carrier 216 to further stabilize staple cartridge 220 within support channel 218.

Staple cartridge 220 includes retention slots 225 for receiving a plurality of fasteners 226 and pushers 228. A plurality of spaced apart longitudinal slots 230 extend through staple cartridge 220 to accommodate upstanding cam wedges 232 of actuation sled 234. A central longitudinal slot 282 extends along the length of staple cartridge 220 to facilitate passage of a knife blade 280. During operation of surgical stapler 10, actuation sled 234 translates through longitudinal slots 230 of staple cartridge 220 to advance cam wedges 232 into sequential contact with pushers 228, to cause pushers 228 to translate vertically within slots 224 and urge fasteners 226 from slots 224 into the staple deforming cavities 206 of anvil assembly 20.

Referring to FIGS. 27 and 28, mounting assembly 202 includes upper and lower mounting portions 236 and 238. Each mounting portion includes a threaded bore 240 on each side thereof dimensioned to receive threaded bolts 242 (See FIG. 21) for securing the proximal end of carrier 216 thereto. A pair of centrally located pivot members 244 (See FIG. 21) extends between upper and lower mounting portions via a pair of coupling members 246 which engage the distal end of housing portion 200. Coupling members 246 each include an interlocking proximal portion 248 configured to be received in grooves 250 formed in the proximal end of housing portion 200 to retain mounting assembly 202 and housing portion 200 in a longitudinally fixed position in relation thereto.

Housing portion 200 of disposable loading unit 16 includes an upper housing half 250 and a lower housing half 252 contained within an outer casing 251. The proximal end of housing half 250 includes engagement nubs 254 for releasably engaging elongated body 14 and an insertion tip 193. Nubs 254 form a bayonet type coupling with the distal end of body 14 which will be discussed in further detail below. Housing halves 250 and 252 define a channel 253 for slidably receiving axial drive assembly 212. A second articulation link 256 is dimensioned to be slidably positioned within a slot 258 formed between housing halves 250 and 252. A pair of blow out plates 255 are positioned adjacent the distal end of housing portion 200 adjacent the distal end of axial drive assembly 212 to prevent outward bulging of drive assembly 212 during articulation of tool assembly 17. Each blow-out plate 255, as illustrated in FIGS. 27, 57, 60 and 61, includes a planar surface which is substantially parallel to the pivot axis of tool assembly 17 and is positioned on a side of drive assembly 212 and the pivot axis to prevent outward bulging of drive assembly 212. Each blow-out plate includes a first distal bend 255a which is positioned in a respective first groove 202a formed in mounting assembly 202 and a second proximal bend 255b which is positioned in a respective second groove 200a formed in a distal end of housing portion 200.

Referring to FIGS. 29-30, second articulation link 256 includes at least one elongated metallic plate. Preferably, two or more metallic plates are stacked to form link 256. The proximal end of articulation link 256 includes a hook portion 258 configured to engage first articulation link 123 (See FIG. 9) and the distal end includes a loop 260 dimensioned to engage a projection 262 formed on mounting assembly 202. Projection 262 is laterally offset from pivot pin 244 such that linear movement of second articulation link 256 causes mounting assembly 202 to pivot about pivot pins 244 to articulate tool assembly 17.

Referring also to FIGS. 31-34, axial drive assembly 212 includes an elongated drive beam 266 including a distal working head 268 and a proximal engagement section 270. Drive

beam 266 may be constructed from a single sheet of material or, preferably, multiple stacked sheets. Engagement section 270 includes a pair of engagement fingers 270a and 270b which are dimensioned and configured to mountingly engage a pair of corresponding retention slots 272a and 272b formed in drive member 272. Drive member 272 includes a proximal porthole 274 configured to receive the distal end 276 of control rod 52 (See FIG. 35) when the proximal end of disposable loading unit 16 is engaged with elongated body 14 of surgical stapling apparatus 10.

The distal end of drive beam 266 is defined by a vertical support strut 278 which supports a knife blade 280, and an abutment surface 283 which engages the central portion of actuation sled 234 during a stapling procedure. Surface 285 at the base of surface 283 is configured to receive a support member 287 slidably positioned along the bottom of the staple cartridge 220. Knife blade 280 is positioned to translate slightly behind actuation sled 234 through a central longitudinal slot 282 in staple cartridge 220 (FIG. 30) to form an incision between rows of stapled body tissue. A retention flange 284 projects distally from vertical strut 278 and supports a cylindrical cam roller 286 at its distal end. Cam roller 286 is dimensioned and configured to engage cam surface 209 on anvil body 204 to clamp anvil portion 204 against body tissue.

Referring also to FIGS. 36-39, a locking device 288 is pivotally secured to drive member 270 about a pivot pin 290. Locking device 288 includes a pair of elongate glides 292 and 294 which define a channel 296. A web 298 joins a portion of the upper surfaces of glides 292 and 294, and is configured and dimensioned to fit within elongated slot 298 formed in drive beam 266 at a position distal of drive member 270. Horizontal cams 300 and 302 extend from glides 292 and 294 respectively, and are accommodated along an inner surface of lower housing half 252. As best shown in FIG. 42, a torsion spring 304 is positioned adjacent drive member 270 and engages horizontal cams 300 and 302 of locking device 288 to normally bias locking device 288 downward toward lower housing half 252 onto ledge 310. Locking device 288 translates through housing portion 200 with axial drive assembly 212. Operation of locking device 288 will be described below.

Sequence of Operation

Referring to FIGS. 40-44, to use stapling instrument 10, a disposable loading unit 16 is first secured to the distal end of elongated body 14. As discussed above, stapling instrument 10 can be used with articulating and non-articulating disposable loading units having linear rows of staples between about 30 mm and about 60 mm. To secure disposable loading unit 16 to elongated body 14, the distal end 276 of control rod 52 is inserted into insertion tip 193 of disposable loading unit 16, and insertion tip 193 is slid longitudinally into the distal end of elongated body 14 in the direction indicated by arrow "A" in FIG. 41 such that hook portion 258 of second articulation link 256 slides within a channel 310 in elongated body 314. Nubs 254 will each be aligned in a respective channel (not shown) in elongated body 14. When hook portion 258 engages the proximal wall 312 of channel 310, disposable loading unit 16 is rotated in the direction indicated by arrow "B" in FIGS. 41-44 to move hook portion 258 of second articulation link 256 into engagement with finger 164 of first articulation link 123. Nubs 254 also forms a bayonet type coupling within annular channel 314 in body 14. During rotation of loading unit 16, nubs 254 engage cam surface 195 (FIG. 41) of block plate 192 to initially move plate 192 in the direction indicated by arrow "C" in FIGS. 41 and 43 to lock engagement member 196 in recess 199 of control rod 52 to prevent longitudinal movement of control rod 52 during

attachment of disposable loading unit 16. During the final degree of rotation, nubs 254 disengage from cam surface 195 to allow blocking plate 192 to move in the direction indicated by arrow "D" in FIGS. 42 and 44 from behind engagement member 196 to once again permit longitudinal movement of control rod 52.

Referring to FIGS. 43 and 43a, when insertion tip 193 engages the distal end of sensor tube 176, the disposable loading unit sensing mechanism is actuated. Insertion tip 193 engages and moves sensor tube 176 proximally in the direction indicated by arrow "E" in FIG. 43. As discussed above, proximal movement of sensor tube 176 effects proximal movement of sensor cylinder 178 and sensor link 182 in the direction indicated by arrow "E" in FIG. 43a to pivot locking member 83 counter-clockwise, as indicated by arrow "Y" in FIG. 43a, from a non-blocking position to a position blocking movement of actuation shaft 46.

Referring to FIGS. 46-49, with a disposable loading unit attached to stapling instrument 10, tool assembly 17 can be positioned about tissue 320 (FIG. 45). To clamp tissue between anvil assembly 20 and cartridge assembly 18, stationary handle 24 is moved in the direction indicated by arrow "E" in FIG. 46 against the bias of torsion spring 40 to move driving pawl 42 into engagement with shoulder 322 on actuation shaft 46. Engagement between shoulder 322 and driving pawl 42 advances actuation shaft 46 and thus advances control rod 52 distally. Control rod 52 is connected at its distal end to axial drive assembly 212 (FIG. 48), including drive beam 266, such that distal movement of control rod 52 effects distal movement of drive beam 266 in the direction indicated by arrow "F" in FIGS. 48 and 49, moving cam roller 286 into engagement with cam surface 209 on anvil portion 204 to urge anvil portion 204 in the direction indicated by arrow "G" in FIG. 49. It is noted that one complete stroke of movable handle 24 advances actuation shaft 46 approximately 15 mm which is sufficient to clamp tissue during the first stroke but not to fire staples.

As discussed above with respect to the anti-reverse clutch mechanism, during the first (clamping) stroke of movable handle 24, slide plate 102 (FIG. 46) prevents locking pawl 54 from engaging toothed rack 48. To maintain actuation shaft 46 in its longitudinal position after handle 24 is released, an engagement member 324 (FIG. 47) is provided on locking member 83 to engage shoulder 326 on actuation shaft 46 and retain shaft 46 in its longitudinal position (See FIG. 47). Upon release of movable handle 24, drive pawl 42 moves over rack 48 as torsion spring 40 returns handle 24 to a position spaced from stationary handle 22. In this position, driving pawl 42 is urged into engagement with toothed rack 48 to retain actuation shaft 46 in its longitudinal fixed position.

In order to fire staples, movable handle 24 is actuated again, i.e., moved through another stroke. As discussed above, stapling apparatus 10 is capable of receiving disposable loading units having linear rows of staples of between about 30 mm and about 60 mm. Since each stroke of the movable handle 24 preferably advances actuation shaft 46 15 mm, and one stroke is required to clamp tissue, the movable handle must be actuated (n+1) strokes to fire staples, where n is the length of the linear rows of staples in the disposable loading unit attached to stapling instrument 10 divided by 15 mm.

Referring to FIG. 50, prior to being able to fire staples, firing lockout assembly 80 (FIG. 4) must be actuated to move locking surface 88 from its blocking position (FIG. 47) to a non-blocking position. This is accomplished by pressing down on plunger 82 to move camming surface 85 into engagement with sidewalls of slot 89 of locking member 83 to pivot locking member 83 in the direction indicated by arrow

“G” in FIG. 50 (see also FIG. 5). Thereafter, movable handle 24 may be actuated an appropriate number of strokes to advance actuation shaft 46, and thus control rod 52 and drive beam 266, distally in the direction indicated by arrow “H” in FIGS. 51 and 52 to advance actuation sled 234 through staple cartridge 220 to effect ejection of staples. It is noted that after the first or clamping stroke of movable handle 54 (during the second stroke), slide 102 passes over locking pawl 54 allowing torsion spring 56 to move locking pawl 54 in the direction indicated by arrow “T” in FIG. 50 into engagement with toothed rack 48 to retain actuation shaft 46 in its longitudinal position.

Referring to FIG. 53, to retract actuation shaft 46 and thus control rod 52 and drive member 266 after firing staples, retraction knobs 32 (see FIG. 1) are pulled proximally causing pins 66 to move release plate 64 in the direction indicated by arrow “J” in FIG. 53 over teeth 48 to disengage drive pawl 42 from engagement with teeth 48. As discussed above, with respect to the anti-reverse clutch mechanism, locking pawl 54 is urged by slide plate 102 out of engagement with toothed rack 48 (not shown) to permit actuation shaft 46 to be moved proximally, in the direction indicated by arrow “L”, after drive pawl 42 is disengaged from teeth 48.

Referring to FIG. 54, in order to retract actuation shaft 46 prior to firing stapling apparatus, i.e., when locking pawl is currently engaged with toothed rack 48, emergency return button 112 is pushed in the direction indicated by arrow “Z” in FIG. 54 to disengage locking pawl 54 from toothed rack 48. Retraction knobs 32 (FIG. 1) must also be concurrently pulled rearwardly, as discussed above, to release drive pawl 42 from rack 48.

Referring to FIGS. 55-61, when an articulating disposable loading unit is secured to elongated body 14 and articulation lever 30 is pivoted in the direction indicated by arrow “M” in FIG. 55, cam member 136 is moved transversely by projection 142 (FIG. 10) in the direction indicated by arrow “N” between flanges 170 and 172 of rotation knob 28. Since translation member 138 is prevented from rotating by ridges 156 (FIG. 13), pin 166, which is fixedly secured to translation member 138, is forced to move along stepped cam surface 148. Movement of pin 166 causes corresponding movement of translation member 138 in the direction indicated by arrow “P” in FIGS. 55 and 56 to advance first articulation link 123 in the distal direction. The distal end of first articulation link 123 engages the proximal end of second articulation link 256 (FIG. 42) which is connected to projection 262 on mounting assembly 202 to advance second link 256 in the direction indicated by arrow “Q” in FIG. 57. Projection 262 is laterally offset from pivot members 244, such that distal advancement of second articulation link 256 causes mounting assembly 202 and thus tool assembly 17 to pivot in the direction indicated by arrow “R” in FIGS. 57 and 58. Note in FIG. 59 that rotation member 28 can be rotated to rotate elongated body 14 about its longitudinal axis while tool assembly 17 is articulated.

FIGS. 60-61 illustrate articulation of tool assembly 17 in the opposite direction to that described above. When second articulation link 256 is retracted by rotating articulation lever 30 in a counter-clockwise direction (not shown) as viewed in FIG. 55, pin 66 is forced to move proximally along stepped camming surface 148, moving translation member 138 and first articulation link 123 proximally. Movement of first articulation link 123 proximally, causes second articulation link 256 to move proximally as indicated by arrow “S” in FIG. 58, to rotate tool assembly 17 in a clockwise direction, as indicated by arrow “T” in FIG. 61.

Referring to FIG. 12, movement of pin 166 (FIG. 9) between adjacent step portions 340 causes tool assembly 17 to articulate 22.5 degrees. Camming surface 148 includes five step portions 340. The third step portion corresponds to the non-articulated tool assembly position, whereas the first and the fifth step portions correspond to articulation of tool assembly 17 to forty-five degrees. Each step portion is flat to retain articulation lever 30 in a fixed position when pin 166 is engaged therewith.

Referring now to FIGS. 37, 39, 62 and 63, the sequence of lockout operation will be described in detail. In FIG. 39, lockout device 288 is shown in its prefixed position with horizontal cams 300 and 302 resting on top of projections 330 formed in the sidewalls of lower housing half 252 (FIG. 37). In this position, locking device 288 is held up out of alignment with projection 332 formed in the bottom surface of lower housing half 252, and web 298 is in longitudinal juxtaposition with shelf 334 defined in drive beam 266. This configuration permits the anvil 20 (FIG. 38) to be opened and repositioned onto the tissue to be stapled until the surgeon is satisfied with the position without activating locking device 288 to disable the disposable loading unit 16.

As shown in FIG. 62, upon distal movement of drive beam 266, locking device 288 rides off of projections 330 (not shown) and is biased into engagement with base lower housing half 252 by spring 304, distal to projection 332. Locking device 288 remains in this configuration throughout firing of the apparatus.

Upon retraction of the drive beam 266 in the direction indicated by arrow “U” in FIG. 62, locking device 288 passes under projections 330 and rides over projection 332 until the distalmost portion of locking device 288 is proximal to projection 332. Spring 304 biases locking device 288 into juxtaposed alignment with projection 332, effectively disabling the disposable loading unit. If an attempt is made to reactuate the apparatus, the control rod 52 will abut a proximal end surface of locking device 288 which surface is diagonally sloped to impart a moment about pivot pin 342 such that the distal end of locking device 288 is rotationally urged into contact with projection 332. Continued distal force in the direction indicated by arrow “W” in FIG. 63, will only serve to increase the moment applied to the locking device thus the locking device will abut projection 332 and inhibit distal movement of the control rod 52.

Referring again to FIGS. 41-44, the disabled or locked disposable loading unit can be removed from the distal end of elongated body 14 by rotating disposable loading unit 16 in the direction opposite to the direction indicated by arrow “B” in FIGS. 41, 42 and 44, to disengage hook portion 258 of second articulation link 256 from finger 164 of first articulation link 123, and to disengage nubs 254 from within channel 314 of elongated body 14. After rotation, disposable loading unit 16 can be slid in the direction opposite to that indicated by arrow “A” in FIG. 41 to detach body 14 from disposable loading unit 16. Subsequently, additional articulating and/or non-articulating disposable loading units can be secured to the distal end of elongated body, as described above, to perform additional surgical stapling and/or cutting procedures. As discussed above, each disposable loading unit may include linear rows of staples which vary from about 30 mm to about 60 mm.

It will be understood that various modifications may be made to the embodiments disclosed herein. For example, the stapling apparatus need not apply staples but rather may apply two part fasteners as is known in the art. Further, the length of the linear row of staples or fasteners may be modified to meet the requirements of a particular surgical procedure. Thus, the

17

length of a single stroke of the actuation shaft and/or the length of the linear row of staples and/or fasteners within a disposable loading unit may be varied accordingly. Therefore, the above description should not be construed as limiting, but merely as exemplifications of preferred embodiments. Those skilled in the art will envision other modifications within the scope and spirit of the claims appended thereto.

While the invention has been illustrated and described as embodied in an apparatus and method for performing surgical tasks, it is not intended to be limited to the details shown, since it will be understood that various omissions, modifications, substitutions and changes in the forms and details of the device illustrated and its operation can be made by those skilled in the art without departing in any way from the spirit or scope of the appended claims.

What is claimed is:

1. A method of performing a surgical procedure comprising:

inserting a disposable loading unit into a distal end of an elongate body;

causing the disposable loading unit to engage a sensing mechanism supported within the elongate body;

displacing a portion of the sensing mechanism to permit movement of a locking member from a first position, wherein the locking member is positioned to permit firing of the disposable loading unit, to a second position, wherein the locking member is positioned to inhibit firing of the disposable loading unit;

manipulating a lockout assembly to permit the locking member to return to the first position, and thereby permit firing of the disposable loading unit; and

firing the disposable loading unit to apply one or more surgical fasteners to tissue.

18

2. The method of claim 1, wherein displacing the portion of the sensing mechanism includes overcoming a bias applied to the locking member by a biasing member.

3. The method of claim 1, wherein displacing the portion of the sensing mechanism includes sliding the portion of the sensing mechanism within the elongate body.

4. The method of claim 3, wherein displacing the portion of the sensing mechanism includes sliding a sensor tube within the elongate body.

5. The method of claim 4, wherein causing the disposable loading unit to engage the sensing mechanism includes causing the disposable loading unit to engage a distal end of the sensor tube.

6. The method of claim 4, wherein sliding the sensor tube within the elongate body includes sliding the sensor tube in a proximal direction away from an end effector of the disposable loading unit.

7. The method of claim 6, wherein sliding the sensor tube within the elongate body includes causing a sensor cylinder and a sensor link to move in the proximal direction away from the end effector of the disposable loading unit.

8. The method of claim 7, wherein moving the sensor link in the proximal direction includes causing an end of the sensor link to move distally to permit movement of the locking member from the first position to the second position.

9. The method of claim 8, wherein moving the sensor link in the proximal direction includes causing the end of the sensor link to move distally of a camming surface formed on the locking member.

10. The method of claim 1, wherein displacing the portion of the sensing mechanism includes moving the locking member into engagement with an actuation shaft.

* * * * *